Fishfriendly Innovative Technologies for Hydropower

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Deliverable 5.3 Public acceptance of alternative hydropower solutions

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<td>Peter Rutschmann (Technical University of Munich)</td>
</tr>
<tr>
<td>Authors</td>
<td>Mandy Hinzmann¹, Holger Gerdes¹, Terese Venus (née Rutkowski)², Tor Haakon Bakken³, Manon Dewitte⁴, Francisco Nunes Godinho⁵, Bendik Hansen⁵, Pedro Eira Leitão⁶, António Pinheiro⁶</td>
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<tr>
<td>Reviewer</td>
<td>Eleftheria Kampa (Ecologic Institute)</td>
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Executive Summary

In many parts of Europe, the public becomes more engaged in questions about the future energy supply of nations and regions. This also applies to the development and operation of hydropower. Public perceptions may influence the realization of projects, including the refurbishment of existing small and large hydropower plants.

In this report, we present results from four European case studies on the public acceptance of hydropower. Q-methodology was used as a means to identify public perceptions and preferences on the modernization, expansion or conversion of hydropower facilities in Europe. The Q-methodology, which is rooted in both qualitative and quantitative research, is a way to systematically study subjectivity or opinions. It is used for studying discourse between different stakeholders in the public sphere and is viewed as a helpful tool in policymaking.

We conducted interviews with citizens in the case study towns Vila Real (Portugal), Toulouse (France), Landshut (Germany) and Örnsköldsvik (Sweden). These towns represent regions with very different geographical characteristics that pose particular challenges for operators seeking to modernise and develop hydropower.

In order to detect relations between opinions on hydropower and the variables age, gender, level of education, country, hydropower knowledge and purchase of green electricity, we applied canonical correspondence analysis (CCA). The analysis revealed that the country where the interview took place was the most important variable to explain differences in respondent’s agreement to the 25 statements used for the interview. Age also influenced the views on hydropower, whereas the remaining explanatory variables were less important in the analysis.

Our results show that a number of similar opinion patterns exist in each case study region. This allowed us to group the respondents into different types of perspectives (or “world views”). Each perspective represents a different opinion, characterised by similar values and perceptions. Specifically, our results reveal that similar perspectives, focusing on the same key issues, exist across the case study towns. These are: (1) hydropower is a climate-friendly energy source and a crucial component for an energy transition; (2) hydropower (potentially) harms river ecosystems; (3) local hydropower plants should bring benefits to the region, and/or should be operated by companies based in the country.

Overall, our study results indicate that hydropower production is not a highly contested topic for the local residents of the four case study regions. However, within the perspectives that we identified, conflicting views exist on a number of issues, namely ecological effects, ownership questions and changes in electricity prices. These points of conflict may drive public debates on hydropower and influence public acceptance. Therefore we believe that it is useful for hydropower operators and planners as well as for politicians to be aware of these issues and consider them in their decisions.

As the negative environmental impacts of hydropower are a central issue in public opinion, designing and implementing environmental mitigation measures presents an opportunity to address public concerns. To this end, operators and political decision-makers will have to develop strategies that demonstrate how specific mitigation measures may enhance the ecological status of the river ecosystem.
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1. Introduction

To fight climate change, a goal of the European Union is transitioning to an energy system based on renewables such as solar, wind, biogas/biomass, geothermal and hydropower. Europe has a long history of hydropower development and many of the sites appropriate for larger hydropower plants have already been developed, sometimes with large ecological impacts. As hydropower plants can have significant impacts on water ecosystems, the EU Water Framework Directive mandates the implementation of restoration and mitigation measures to tackle pressures on water ecosystems from hydropower plants. Public support plays an important role in maintaining existing hydropower and realizing further hydropower development, but little is known about how the public perceives hydropower.

Hydropower is considered a climate-friendly and cost-efficient renewable energy source (Kumar et al., 2011). In a global context, Europe has exploited the highest portion of the technical hydropower potential. A large part of the existing hydropower plants (HPPs) in Europe has been in operation for many decades and are ready for refurbishment, upgrading and potential expansion. In fact, hydropower has undergone decades without major technical innovations.

In many parts of Europe, the public becomes more engaged in questions about the future energy supply of nations and regions. On the one hand, this is apparent in national-level decision-making about the structure of the future energy system (e.g. fossil-based vs. renewable). On the other hand, this concerns the practical implementation of energy projects at the local level – including renewable energy projects in the areas of bioenergy, wind power, solar power and hydropower. For planners and operators at the local level, this implies that the realization of individual projects is increasingly subject to public acceptance. Opposition among the public, including among organized citizen groups, may slow down the planning and implementation processes, or even prevent the realization of projects. Therefore, “well-informed public preferences are key to enabling successful and sustainable energy transitions worldwide” (Volken et al., 2017).

In the context of hydropower, public acceptance is generally determined by the size of a project. Even in the case of smaller hydropower plants, public perceptions may influence the realization of projects, including the refurbishment of existing power plants. Focusing on four regional case studies in Germany, France, Portugal and Sweden, this report investigates the public viewpoints with regard to small-scale hydropower installations, for which little research exists, and elaborates by which factors these viewpoints are determined. Even though small hydropower plants are perceived to have small ecological effects, many small plants along the same river can lead to a large cumulative impact. On this background, the report discusses which effects the implementation of mitigation measures may have on the public acceptance of existing hydropower plants.
2. State of the Art: Public Acceptance of Hydropower in Europe

Due to the boost of renewable energy technologies, in the last decade, the scientific community has intensely explored and discussed the public acceptance of such technologies (Qazi et al. 2019; Tabi and Wüstenhagen 2017). Many politicians view renewable energies (RE) as key to a climate-friendly future, energy security and energy independence (Moula et al. 2013; Qazi et al. 2019). Without public support, a transition to a climate-friendly energy system will be difficult to realise. Therefore, acceptance studies aim to inform decision-makers about public perceptions and concerns to:

- Enable better planning and implementation of policies.
- Address potential resistance against RE projects.

Energy providers should know and understand public attitudes and concerns towards renewable energy solutions to address critical issues in the planning stage (Koch et al. 2015). Concerns should be known early in the planning process, as resistance against RE projects on the local level can delay their completion (Ribeiro, Ferreira, and Araújo 2011) – which may be costly for energy companies (Tabi and Wüstenhagen 2017).

Moreover, Ntanos et al. (2018) argue that “citizens’ active participation promotes the implementation of the renewable energy targets agreed upon by the national governments.” For example, citizens can support renewable energy solutions by demanding and purchasing green electricity, or by making green investments in the RE sector.

In Europe, researchers explore the acceptance of various renewable energy solutions at different geographical levels, ranging from case-study towns to country or regional level. Overall, the studies show that a positive attitude towards renewable energies – including hydropower – prevails among the European public (e.g. Botelho et al. 2016; Chiciudean et al. 2018; Ntanos et al. 2018; Ribeiro et al. 2014; Saha and Idsø 2016).

However, social scientists observed that there is a difference between the general attitude towards renewable energies among the national population and acceptance for specific RE technologies at the local level (Botelho et al. 2016; Schumacher et al. 2019; Wüstenhagen, Wolsink, and Bürer 2007). For the case of hydropower, a recent acceptance study in Switzerland illustrated this phenomenon. The authors studied and compared the public support for a) the national energy transition goals and b) for implementing specific RE technologies. They found that “the support for increasing HP production is higher than that of heightening a dam or building a new plant in a periglacial area” (Blumer et al. 2018, 14). As an explanation, the authors hypothesize that citizens do not always see the connection between the political targets they support and specific measures that have to be taken to achieve them. Rather, citizens somehow perceive the implementation of RE technologies as something separate from overall policies. This has also been described by Aas et al. (2014) in that acceptance can be empirically distinguished from support.
Botelho et al. (2016) offer a different explanation. They point out that the construction and operation of RE facilities such as wind turbines, biogas units or hydroelectric plants in particular affect local residents living nearby. They argue that all RE technologies, despite their various benefits, have a number of negative effects in common: they impact the landscape, they occupy land which cannot be used for other purposes and they affect species and habitats. These effects are mostly felt by the local communities.

Closely related to this is the discussion about the “Not-In-MY-Backyard (NIMBY)” syndrome, which comes up frequently in RE acceptance studies (e.g. Blumer et al. 2018; Botelho et al. 2016; Moula et al. 2013; Schumacher et al. 2019). It refers to the observation that individuals, while supporting the general idea of RE, oppose the establishment of RE in the area where they live. A number of researchers criticized the NIMBY concept for being too simplistic and for not taking into account the multiple factors that might influence an individual’s acceptance (Botelho et al. 2016; Devine-Wright 2009; Hullinger et al. 2015; Schumacher et al. 2019; Wüstenhagen, Wolsink, and Bürer 2007). Devine-Wright (2009) suggested that NIMBY-reactions should rather be understood as ‘place-protective actions’, meaning that strong emotional attachment to a place can lead to resistance against changes caused by RE projects. Such place attachment can also lead to support for local RE development, in case the new project is perceived as an opportunity for the region.

To better account for the complex motives of individuals, Wüstenhagen, Wolsink and Bürer (2007) differentiate between the social-political dimension of acceptance and community acceptance. The former describes the social acceptance of policies or technologies on a broader, general level. An example of this is the positive public attitude found in many countries towards the idea of producing clean energy from renewable sources like wind, sun and water. In contrast, community acceptance describes how local stakeholders (e.g. residents) perceive specific RE projects and decisions on the local level.

Building on this, Schumacher et al. (2019) argue: “Whereas opinion polls assess public acceptance of RE technologies as such, the acceptance of specific RE projects needs to be assessed on a case by case basis including the project’s inherent characteristics (such as ownership structure, participation possibilities, siting etc.)” (Schumacher et al. (2019)p. 34).

Most acceptance studies on RE in Europe focus on wind, biomass and solar energy, while in comparison rather few studies take a closer look at hydropower solutions (compare Tabi and Wüstenhagen 2017). The literature review showed that there are several topics relevant to the public perception of hydropower. We clustered these topics as follows:
Research has shown that for acceptance of hydropower at the local level, it is essential how residents and stakeholders perceive the distribution of economic costs and benefits in their community. Tabi and Wüstenhagen (2017) describe this as the perception of ‘distributional justice’. Similarly, Malesios and Arabatzis (2010) stated that “The local residents want to participate in terms of economic benefits instead of just bear costs like changes of the landscape” (p. 28). Thus, local residents are more likely to perceive hydropower positively when they can observe economic gains in their region, such as job creation, tax revenues or providing stable access to electricity in remote areas (Tabi and Wüstenhagen 2017; Gurung et al. 2016; Bergmann, Colombo, and Hanley 2008; Saha and Idsø 2016). Also, low electricity prices related to local hydropower production can be perceived as a benefit (Malesios and Arabatzis 2010). Other studies confirm that the level of electricity prices influences public perception of RE technologies (Koch et al. 2015; Chiciudean et al. 2018). Apparently, this applies in both directions: Gullberg et al. (2014) found that consumers, as well as energy-intensive industries in Norway, tend to oppose new hydropower developments that could lead to a rise in energy prices. Not surprisingly, locals who are involved with RE and benefit directly from them, e.g. individuals being employed in the RE sector or holding shares in RE production, have a more positive attitude (Botelho et al. 2016; Schumacher et al. 2019). Acceptance can be hampered when local hydropower projects are perceived to negatively affect other sectors, such as agriculture (Ribeiro, Ferreira, and Araújo 2011). On a broader level, improving energy security and gaining energy independence might be seen as a further economic benefit of hydropower (Qazi et al. 2019; Karlstrom and Ryghaug 2014).

Hydropower production can affect the quality of life of the local population in various ways. One important aspect is that hydropower plants cause changes in the landscape. Citizens could perceive them as disrupting the natural scenery, and / or threatening the cultural heritage of a region (Saha and Idsø 2016; Botelho et al. 2016; Koch et al. 2015). Moreover, constructing and operating hydropower sites might impede recreational opportunities of a river site such as
fishing, swimming or boating (Saha and Idsø 2016; Bakken et al. 2012; Loubier et al. 2005). Hydropower dams can in particular negatively affect angling opportunities, as they impede migration of fish. By disconnecting rivers, hydropower also sets limits for water sports such as kayaking. Depending on the local conditions, however, citizens might also feel that hydropower installations enhance recreational opportunities – for example through the creation of artificial lakes (Mattmann, Logar, and Brouwer 2016). Klingmaier et al. (2012) showed that in a case study in Austria, citizens preferred the construction of hydropower that creates new recreational opportunities.

Concerns about the deterioration of drinking water quality (Saha and Idsø 2016) or noise generated by hydropower plants (Botelho et al. 2016) can also be relevant for acceptance. The same applies to security issues related to hydropower production (Burgherr and Hirschberg 2014). Next to dam failures, there is an increased risk for accidents such as drowning near hydropower plants. A Swedish study pointed out that apart from causing death or injuries, the perceived threats along regulated rivers cause distress and anxiety for the local inhabitants (Öhman, Palo, and Thunqvist 2016). In Switzerland, citizens estimated the risk of accidents related to hydropower as low (Volken, Wong-Parodi, and Trutnevyte 2019).

In regions with a long history of hydropower and high energy generation share, the technology has been central to the “nation-building process” (Lindström and Ruud 2017). In this way, it is a source of pride for these nations as it has enabled significant rural and urban development and industrialization. This is particularly relevant in Scandinavia as well as the Alpine region. Pride in the technology is also closely linked to energy independence. When hydropower accounts for a large share of energy production, nations are autonomous and less sensitive to fluctuations in the political setting. For example, Austrian hydropower development increased significantly after World War I in response to the limited coal supply from its former territories (Wagner et al. 2015).

The perception of ecological effects also plays a decisive role in public acceptance. In their nationwide representative study on social acceptance of hydropower projects in Switzerland, Tabi & Wüstenhagen (2017) found that „concerns about ecological impacts lead to lower levels of acceptance“ (p. 770). A further Swiss study showed that the major concerns against hydropower relate to ecological effects: Next to fearing that hydropower production could harm river animals and plants, respondents of the study were concerned about the additional costs for mitigating these negative effects on the river ecosystem (Koch et al. 2015). In a Greek case study on local resident’s attitudes towards hydropower, Malesios and Arabatzis (2010) revealed that negative effects on the environment “were the most profound reasons for protest and negative attitudes against the utilization of electricity from small hydropower stations” (p. 28). Moreover, in a comparison of different types of renewable energies, Portuguese residents perceived hydropower (together with biomass) as more harmful to the environment than solar and wind energy (Ribeiro et al. 2014).

On the other hand, contributing to climate change mitigation is the most important positive environmental effect the public sees in hydropower (Mattmann, Logar, and Brouwer 2016; Karlström and Ryghaug 2014; Gullberg, Ohlhorst, and Schreurs 2014). Hydropower is seen as a green and clean way of producing electricity (Klingmair, Bliem, and Brouwer 2015). This in general positively influences public attitudes towards hydropower. However, some studies have shown that acceptance decreases when people consider the negative environmental
impacts to be higher than the benefits of greenhouse gas reduction (Tabi and Wüstenhagen 2017; Mattmann, Logar, and Brouwer 2016; Gullberg, Ohlhorst, and Schreurs 2014).

According to the literature, enabling public participation in the decision-making and planning process of hydropower development is a decisive factor for public acceptance (e.g. Díaz, Adler, and Patt 2017; Koch et al. 2015). For example, Saha and Idsø (2016) explored attitudes towards new hydropower development across various municipalities in Norway. Among the most important reasons for stakeholders not to support new hydropower projects was the lack of participation opportunities for the municipality. Tabi and Wüstenhagen (2017) confirmed for the case of Switzerland that the ability for citizens to participate in the decision-making process of hydropower development enhances acceptance. Yet, the authors point out that participation alone is not a guarantee for high acceptance. Rather, project implementers need to understand people’s concerns and address them during the planning process.

Regarding energy policy, issues like state subsidies and state ownership of hydropower facilities play a role for acceptance. For example, Ntanos et al. (2018) find that public acceptance of hydropower is higher when the state promotes its expansion and subsidizes hydropower production in an urban municipality in Greece. Tabi and Wüstenhagen (2017) showed that in Switzerland the question of who owns hydropower plants influences public acceptance: “The Swiss residents we surveyed report that whether a hydropower plant is owned by a local or cantonal utility, a private domestic company or a foreign investor is important to them – with preferences decreasing in that order” (p. 771). In fact, the authors revealed that Swiss citizens strongly opposed foreign ownership of plants. On the other hand, the community (co-ownership) of hydropower plants often enhances acceptance (Schumacher et al. 2019).

A number of acceptance studies explored energy preferences by comparing public attitudes towards different forms of renewable energies (e.g. Schumacher et al. 2019; Ribeiro et al. 2014; Koch et al. 2015). For example, Botelho et al. (2016) explored public perception of four types of RE (wind, solar, hydropower, biomass) in Portugal. The authors found that solar and wind energy are preferred over hydropower, while biomass was the least supported form of renewable energy. The main reason for this order of preferences was the perception of environmental friendliness. Similarly, Koch et al. (2015) revealed that the Swiss people prefer solar energy to hydropower, but that hydropower was clearly preferred over biomass power. As reasons for the latter, respondents stated hydropower was preferable to biomass because it does not compete for land needed for food production, it does not cause malodor nor does it cause an increase in traffic. In addition, the Swiss viewed hydropower generally more positively than wind power, as they perceived wind power to be more disturbing to the natural scenery. Moreover, it was argued that acceptance of hydropower is enhanced by the fact that it is the most known and acknowledged renewable energy, as it had been established in European countries for many decades (Ribeiro et al. 2014).
3. Method & Materials

3.1 Description of case study regions

The case study regions in FIThydro include the Alpine region, France/Belgium (representing the European Plain), the Iberian Peninsula and Scandinavia. Their geographies present unique challenges for operators looking to modernize and develop hydropower. As surveys in all countries in the regions were not feasible, we selected one representative country from each.

For the Alpine region, we selected Germany. Although Austria and Switzerland have a larger share of hydropower in their electricity mix, we selected Germany as there have been very few studies on German perception of hydropower.

For France/Belgium, we selected France because hydropower is more developed in France, as there are more mountains. In addition, a larger number of FIThydro test cases are located in France.

For the Iberian Peninsula, we selected Portugal, because renewables are expected to increase their share in the electricity produced in the country to reach carbon neutrality by 2050. Nevertheless, the implementation of new hydropower plants, including small ones, is being hampered by several constraints, including some public perception about its negative impacts. Moreover, there have been very few studies on Portugal perception of hydropower. The Vila Real city was chosen as several small hydro exists. Moreover, the selected hydropower (Terragido) is situated in the Douro river catchment which is shared between Portugal and Spain.

For Scandinavia, Anundsjö is the only FIThydro test case so it naturally became the case for the social acceptance study. The reason for choosing Anundsjö as a test case was due to the HPP having multiple challenges concerning mitigation measures, as well as a large social engagement from local communities.

The following locations were selected as case studies within each case study region: Toulouse (area) in France, Landshut in Germany, Vila Real in Portugal and Örnsköldsvik in Sweden. We selected our case studies based on comparable criteria for the hydropower plant and the surrounding area/interview sites. For the hydropower plant, we established the following criteria:

(i) Run-of-river scheme.
(ii) Less than 20 MW in capacity.
(iii) Ecological measure (e.g. fish ladder) in place.
(iv) Within a 15km radius to an urban area.

The interview sites were selected based on the following criteria:

(i) Urban areas needed to be comparable in size.
(ii) Smaller towns were preferred (population less than 100,000 people) to focus on locals rather than those who recently moved to the area.
(iii) Interview sites must be accessible via public transportation.
The hydropower plant of Las Rives (France) is located at the Ariège river in the south of France. It was built in 1918 and is a run-of-river HPP. It has a production of 12 GWh per year. It is operated by ONDULIA, a French company, which also operates 3 other HPPs on the Ariège. Since its construction, several mitigation measures have been implemented and improved. The dam and the HPP represent a barrier to upstream and downstream migration of fish. In 1987, a pool-type fishway was built. Between 2014 and 2017, several mitigation measures have been installed to protect downstream migrating fish, especially an inclined bar rack guiding fish to the bypassed reach. The water catchment is subject to floods and is included in a regional plan to fight against floods. The river is a recreational area (fishery, kayaking, etc). Four interview sites were included: (i) Place St Pierre-Toulouse (near the biggest hydropower plant, Bazacle, in Toulouse), (ii) Pamiers (biggest city near Las Rives, a FIThydro test case), (iii) P’ Institute – Poitiers and (iv) Institut de mécanique des Fluides de Toulouse (IMFT), which is close to both the hydropower plants of Bazacle and Ramiers.

Figure 2: Geographical location of the French case study town Toulouse
The hydropower plant of Altheim (Germany) is located on the Isar river in the south of Germany. Altheim is a test case within the FIThydro project and is owned by Uniper Hydro Germany. Uniper operates 109 hydropower plants on southern German rivers. The plant was first commissioned in 1951 and is one of several hydropower plants along the Isar river. The Isar river is the fourth largest river in the southern German state of Bavaria and an important tributary to the Danube river. The presence of various hydropower plants, including Altheim, have created pressures on the water ecosystem including nutrient loss, river and agricultural pollution as well as hydromorphological changes. The interviews were conducted in the city main square and market of Landshut.

Figure 3: Geographical location of the German case study town Landshut

The hydropower plant of Terragido (Portugal) is located along the Corgo river in the North of Portugal. The plant began operation in 1992 and was the first hydropower plant in the Vila Real district. It is operated by EDP, a private company based in Portugal. Today, Terragido is one of many hydropower plants in the district. These were built between 1993 and 2008. Flooding is a major problem in the Corgo river and other tributaries of the Douro river. The Corgo river is also used for recreation and irrigation. Some sewage plants discharge into the Corgo river as well. Despite these uses, the industrialization of the river is considered low but the water body is considered below good ecological status. The team conducted interviews in several locations across Vila Real including near the city hall, the main market and the university campus.

Figure 4: Geographical location of the Portuguese case study town Vila Real
The hydropower plant of Anundsjö (Sweden) is located along the Mo river in the north of Sweden. The plant is one of three hydropower plants along the lower part of the river. The hydropower plant was built in 1953 and currently has several measures in place to reduce its ecological impact, including a smolt trap and a VAKI fish counter. The plant is operated by the Norwegian State-owned company Statkraft. The river basin is protected within the NATURA 2000 network and further hydropower development has been prohibited. The team conducted interviews in various locations in the nearby town of Örnsköldsvik including the city library, the mall and the city centre.

![Geographical location of the Swedish case study town Örnsköldsvik](image)

**Figure 5: Geographical location of the Swedish case study town Örnsköldsvik**

### 3.2 Overview of Q-methodology

The Q-methodology (henceforth Q-method or Q-study) is rooted in both qualitative and quantitative research. As described by Brown (1993), it is a way to systematically study subjectivity or opinions. Today, it is used for studying discourse between different stakeholders in the public sphere and is viewed as a helpful tool in policymaking (J. Barry and Proops 1999). In its simplest form, participants are given a list of opinion statements and they are asked to rank them according to how much they agree or disagree with a given statement. The patterns of each individual can then be analysed. The main components of the Q-method include (i) identification of the concourse (ii) development of the Q-set (iii) identification of the P-set (iv) Q-sorting (v) factor analysis and interpretation. These are explained in further detail below.

According to Brown (1993), a concourse should summarize the ideas related to a certain topic and can be collected through interviews, literature reviews and essays. In some cases, the concourse can be summarized in a concourse matrix, which allows researchers to organize ideas about a given issue (J. Barry and Proops 1999). The Q-set refers to the specific opinion statements about a given concept. There are a variety of guidelines for creating an appropriate Q-set. Watts & Stenner (2005) recommend that the Q-set is balanced (i.e. approximately equal in terms of pro and contra statements), singularly expressed (only one idea per statement) and that the Q-set covers all ideas relevant to the topic. To ensure that all ideas are covered by the Q-set, validation exercises with experts and pilot surveys can be used. Additionally, the appropriate sample needs to be identified. The sample in a Q-study is often referred to as the P-set. Compared to other studies, the validity of the Q-method hinges on its strategically
selected sample. For this reason, the sample itself can be small so long as the quality is maintained. A Q-study is valid with approximately 40 to 60 (or fewer) individuals (Watts and Stenner 2005). They are not designed for large completely randomized studies. Thus, the results cannot be generalizable (Amin 2000). The P-set (participants) then sort the Q-set (statements) based on their agreement with each opinion. This is referred to as the Q-sort.

The Q-sorts can be statistically analysed and reduced with factor extraction, rotation and estimation. This entails building a correlation matrix of the respondents’ Q-sorts. If respondents load significantly on a given factor, they are assumed to have a similar opinion on the topic. The standard methods of statistical analysis are centroid factor analysis (FA) or principal component analysis (PCA) with either judgmental or varimax rotations of the data (Dziopa and Ahern 2011). Practitioners can select their statistical analysis method based on their underlying assumptions: FA is used to group together participants whereas PCA is used to extract factors (Dziopa and Ahern 2011). The results from either PCA or FA are said to be quite similar, but not identical (Zabala and Pascual 2016). PCA is often used in the Q-literature, but researchers often refer to the extraction of “factors” although the extraction of “components” would be the correct terminology. For consistency, Zabala & Pascual (2016) recommend using the term “factor” even when PCA is employed.

The results can be interpreted based on the factor arrays (listing of different rankings). Here, it is important to pay attention to the top and bottom rows as they represent the most extreme opinions (Dziopa and Ahern 2011). These are said to characterize each factor. It is also important to look at the statements ranked as “distinguishing” and “consensus” as they indicate unique opinions and those shared across factors (Zabala 2019).

Our application of the Q-method includes a detailed literature review to develop the concourse and the Q-set and P-Set, an intensive validation round using stakeholder workshops, expert interviews and a pilot survey, the surveys and analysis of the surveys.

3.2 Applications of the Q-Method in Renewable Energy Studies

There have been a number of previous applications of the Q-method to studies of renewable energy technologies and public perception. These studies are summarized in Table 1. There were two studies identified which focused on wind power. Ellis, Barry & Robinson (2007) studied wind farm proposals with a case study in Northern Ireland. They found several important policy implications for public participation in the planning process, especially that participation needs to be a two-way rather than a one-way process and that giving information about wind proposals to the public should not be expected to dissolve opposition. In contrast, Wolsink & Breukers (2010) also studied wind power development but used a p-set which included stakeholders from different countries, specifically the Netherlands, Germany and England. Cuppen, Breukers, Hisschemöller, & Bergsma (2010) used the Q-method to select stakeholders for dialogues. They found that the type of actor (e.g. NGOs, industry, etc.) is not a good proxy for beliefs, as there is heterogeneity within each actor type. Cotton & Devine-Wright (2011) used the Q-method to study electricity transmission lines in the United Kingdom. They conclude that there is a range of local perspectives, which demonstrates that the “NIMBY” (Not-in-my-backyard) conceptualization is limited.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Region</th>
<th>Focus</th>
<th>Q-Set</th>
<th>P-Set</th>
<th>Factors</th>
<th>Cumulative Variance Explained (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind Power</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ellis, Barry &amp; Robinson (2007)</td>
<td>Northern Ireland</td>
<td>Wind Farm Proposals</td>
<td>50</td>
<td>53</td>
<td>4</td>
<td>62</td>
</tr>
<tr>
<td>Wolsink &amp; Breukers (2010)</td>
<td>International: Netherlands, North-Rhine Westphalia (Germany) and England</td>
<td>On-shore wind power development</td>
<td>60</td>
<td>56</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuppen, Breukers, Hisschemöller, &amp; Bergsma (2010)</td>
<td>Netherlands</td>
<td>Energy options from biomass</td>
<td>60</td>
<td>75</td>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td><strong>Transmission lines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton &amp; Devine-Wright (2011)</td>
<td>United Kingdom</td>
<td>Transmission line sitting</td>
<td>60</td>
<td>25</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td><strong>Shale Gas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton (2015)</td>
<td>United Kingdom</td>
<td>Shale gas fracking</td>
<td>40</td>
<td>28</td>
<td>3</td>
<td>59</td>
</tr>
<tr>
<td>Cuppen, Bosch-Rekveldt, Pikaar, &amp; Mehos (2016)</td>
<td>Netherlands</td>
<td>Shale gas exploration</td>
<td>49</td>
<td>19</td>
<td>6</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Photovoltaic Systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naspetti, Mandolesi, &amp; Zanoli (2016)</td>
<td>Italy</td>
<td>Visual Q-sort of photovoltaic systems</td>
<td>54</td>
<td>34</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td><strong>Hydropower</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diaz, Adler &amp; Patt (2017)</td>
<td>Switzerland</td>
<td>Hydropower Plant</td>
<td>34</td>
<td>26</td>
<td>3</td>
<td>48.9</td>
</tr>
<tr>
<td>Pagnussatt, Petrini, Santos, &amp; Silveira (2018)</td>
<td>Brazil</td>
<td>Impacts of small hydroelectric plants</td>
<td>26</td>
<td>29</td>
<td>5</td>
<td>59.3</td>
</tr>
</tbody>
</table>
3.4 Development of the Q-Set

We developed our set of statements based on a review of a) the relevant literature as well as b) media coverage of the different FIThydro regions (Alpine region, Iberian peninsula, Scandinavia and France). For the literature search, we used ScienceDirect and Google Scholar. As search strategy, we started with the following search string: hydropower AND ("public acceptance" OR "public perception" OR “public resistance”) AND (France OR Spain OR Portugal OR Norway OR Sweden OR Germany OR Austria OR Switzerland). Next, we added further search terms for each country to find more literature or to get more targeted results, e.g. hydropower AND modernisation; “river restoration” AND “public acceptance”, etc. We applied the snowball system to find further relevant research articles. To identify relevant online newspaper articles and contributions in other reliable online media such as blogs, we searched Google News with the same search words. Here, we partially conducted the search in the local languages. In addition, we conducted two expert interviews to gather further information on relevant topics and to add missing aspects.

Next, we reviewed our collected information and gathered text passages that described opinions on hydropower of the public or of different stakeholder groups. Based on these text passages, we derived 140 opinion statements that refer to hydropower and that each only present a single idea (cf. Watts and Stenner 2005). To structure the statements and to gain a better overview we followed the approach described by Díaz et al. (2017), which is to define categories and assign the statements accordingly. This clustering of statements enabled us to easily delete duplicates and to merge similar ideas or very detailed statements into more general ones. For this, we introduced sub-categories. We took care to ensure that different opinions, schools of thought and political views were adequately covered. With a more manageable set of 38 statements, we entered a validation and pre-testing phase first with hydropower experts at three regional FIThydro stakeholder workshops, and later with laypersons. Based on the gathered feedback, we adapted the phrasing and further reduced the number of statements to 25. The final Q-set was then translated to the local language by native speakers. The English version of the statements, which served as the basis for translation, is presented in Table 2. The table also includes the main categories and sub-categories.
<table>
<thead>
<tr>
<th>Category</th>
<th>Sub-category</th>
<th>No.</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic costs &amp; benefits</td>
<td>Economic development</td>
<td>1</td>
<td>It is important to me that hydropower creates jobs in the region (e.g. construction, maintenance, tourism).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>I am concerned that hydropower negatively affects tourism.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>I am concerned that hydropower negatively affects agriculture and forestry.</td>
</tr>
<tr>
<td></td>
<td>Energy prices</td>
<td>4</td>
<td>Low electricity prices are important to me.</td>
</tr>
<tr>
<td></td>
<td>Energy security</td>
<td>5</td>
<td>It is important to me that hydropower allows [name of country] to reduce energy imports.</td>
</tr>
<tr>
<td></td>
<td>Recreational opportunities</td>
<td>6</td>
<td>Recreational opportunities on rivers are important to me (e.g. fishing, bathing, boating, going for a walk).</td>
</tr>
<tr>
<td>Quality of life</td>
<td>Flood protection</td>
<td>7</td>
<td>It is important to me that hydropower dams protect citizens from floods.</td>
</tr>
<tr>
<td></td>
<td>Health and safety issues</td>
<td>8</td>
<td>I am concerned that hydropower negatively affects the quality of drinking water.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>I am concerned about accidents linked to hydropower plants (e.g. drowning, dam breaks).</td>
</tr>
<tr>
<td></td>
<td>Place attachment</td>
<td>10</td>
<td>I do not want to live near a hydropower plant.</td>
</tr>
<tr>
<td></td>
<td>Cultural identity</td>
<td>11</td>
<td>I am proud of [name of country]'s hydropower.</td>
</tr>
<tr>
<td></td>
<td>Ideal of nature</td>
<td>12</td>
<td>Rivers are meant to flow freely.</td>
</tr>
<tr>
<td></td>
<td>Landscape aesthetics</td>
<td>13</td>
<td>Hydropower plants disturb the natural scenery.</td>
</tr>
<tr>
<td>Ecological effects</td>
<td>Biodiversity and habitats</td>
<td>14</td>
<td>I am concerned that hydropower disturbs natural habitats.</td>
</tr>
<tr>
<td></td>
<td>Fish safety</td>
<td>15</td>
<td>Hydropower should be fish-friendly.</td>
</tr>
<tr>
<td></td>
<td>Emissions</td>
<td>16</td>
<td>I appreciate that hydropower fights climate change.</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
<td>17</td>
<td>If citizens disagree with the (re)construction of a hydropower plant, it should not be built.</td>
</tr>
<tr>
<td>Public participation</td>
<td>Profit-sharing</td>
<td>18</td>
<td>Local municipalities should receive part of the profit from hydropower production.</td>
</tr>
<tr>
<td>Energy policy</td>
<td>Ownership</td>
<td>19</td>
<td>Hydropower plants should not be owned by foreign companies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Hydropower plants should be owned by the state.</td>
</tr>
<tr>
<td></td>
<td>Subsidies</td>
<td>21</td>
<td>[name of country] needs to financially support the expansion of hydropower.</td>
</tr>
<tr>
<td></td>
<td>Comparison to other</td>
<td>22</td>
<td>I prefer hydropower to other forms of renewable energy.</td>
</tr>
<tr>
<td></td>
<td>renewables</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modernization</td>
<td>23</td>
<td>Existing hydropower plants should be modernized before new ones are built.</td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>24</td>
<td>I appreciate that hydropower is a flexible energy source.</td>
</tr>
<tr>
<td>Energy preferences</td>
<td>Energy storage</td>
<td>25</td>
<td>I appreciate that hydropower can store energy.</td>
</tr>
</tbody>
</table>
For the ranking of the statements, a Q-board is used, i.e. a template on which the participant can allocate each of the 25 statements according to his or her individual preferences. To be able to conduct the survey in the field, i.e. in city centres and recreational areas where we aimed to ask local residents to participate, we printed the Q-Board on posters and laminated them to be waterproof. The statements were printed on cards in sufficient font size to be easy to read and were also laminated. To be suitable for an outdoor survey, we attached Velcro to each field of the Q-Board and to the statements so that the sorting would stick – even if the survey is filled in standing or in case of wind. Furthermore, we slightly adapted the “classical” Q-board design, which is usually used for indoor sorting with selected participants. First, we added the guiding question “What do you think about hydropower in your region” in big letters to the top of the board. Second, we used different colours for each level of agreement, indicating that putting statements to the same level (i.e. row) means that the same value is attached. Both adaptations eased the sorting exercise and at the same time helped raising the attention and interest of bypassing residents. The design of our Q-boards is shown in Figure 6.

![Figure 6: Design of Q-board (English version)](image)

### 3.4 Surveys in the field

We randomly selected participants for the survey in each of our case study towns. To ensure that participants are locals, we asked them if they live in the district. If not, we asked for their postal code. This allowed us to conduct face-to-face interviews and a paper sorting exercise. We also considered an online Q-sorting exercise but decided against this because we felt the
ability to give qualitative responses verbally was crucial for our analysis. We also considered a face-to-face interview with a digital Q-sorting (e.g. on a tablet), but decided against this as the paper Q-sort attracted more attention of passers-by.

### 3.6 Descriptive Statistics

In total, 257 individuals were included in the analysis.\(^1\) Table 3 provides an overview of the number of citizens per region whose responses we included in the analysis. In fact, the number of citizens we interviewed in each case study town was higher. Yet we had to sort out some of the responses because they were not complete, participants had lost their motivation halfway through the sorting exercise, responses were illogical or respondents had their place of residence outside the case study district.

<table>
<thead>
<tr>
<th>Table 3: Number of survey participants per case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toulouse (France)</td>
</tr>
<tr>
<td>46</td>
</tr>
</tbody>
</table>

The following figures provide a descriptive overview of the respondents in the sample. We collected information about respondent age, educational status and gender as well as their own rating of their knowledge of hydropower and whether they purchase green electricity. The first three demographic questions were important for understanding baseline characteristics of our sample. The respondents’ own rating of their knowledge of hydropower helped us to judge their background on the topic. Whether consumers select a green electricity tariff is a good indicator of a household’s sustainability preferences (Gerpott and Paukert 2013).

Figure 7 shows the distribution of age across respondents. The sample from France shows a relatively equal distribution across the age groups with the most respondents between the ages of 45 and 54. In the German sample, participants were mainly between the ages 15 to 24 as well as 45 to 54. The Portuguese sample shows the greatest discrepancy in age with a large portion of the respondents between the ages of 45 to 54, followed by 15 to 24. The Swedish sample, the majority of participants are between the ages of 15 to 24. The younger samples in Germany and Sweden is likely because both are student cities. Vila Real is also a student city but our sample reflects an older demographic on average.

\(^1\) The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.
Figure 7: Age of respondents

Figure 8 reflects the educational status of the respondents based on the highest level of education they had achieved. Respondents could choose between several levels including primary school, secondary school, A-levels, Bachelor’s degree, Master’s degree (or Diploma), Doctorate (or equivalent) or other. In our pilot study carried out in August 2018, we tested an open-ended question about the occupation of the respondent but instead opted for a question about educational status. It is also important to note the link between age and educational status. Many respondents were students currently in the process of completing their studies and thus could only indicate the last completed educational level (e.g., Bachelor’s student has only attained A-levels). The French sample reflects a relatively equal spread across the different educational categories. The German sample shows that a large share of respondents had completed secondary, A-levels and Master’s degrees. In the Portuguese sample, an overwhelming number of participants completed a Master’s degree. This is likely correlated to the older age of many respondents. In the Swedish sample, a large share of the respondents completed secondary school, which is likely linked to the younger age of many respondents.
Figure 8: Educational status of respondents

Figure 9 shows the gender distribution of the respondents across the regions. In general, the samples across all regions included more males than females, particularly in the French and Swedish samples.
Figure 9: Gender distribution of the respondents

Figure 10 shows the respondents’ own rating of hydropower knowledge. They rated their knowledge on a scale of 1-5 with 1 representing not knowledgeable and 5 representing very knowledgeable. Most respondents rated their knowledge from 2-3, which represents below average knowledge to average knowledge.
Figure 10: Respondents’ own rating of hydropower knowledge

Figure 11 shows whether respondents purchased green electricity. They also had the option to respond that they do not know. In the French sample, a large share either purchased green electricity or did not know. Comparatively, in the German sample, the largest share did not purchase green electricity. In the Portuguese and Sweden sample, the largest share did not know whether they purchased green electricity. Because the tariffs differ across the regions, it is most interesting to note that a large share of respondents were unaware of their electricity tariffs even when it is relevant to their electricity bill and they have the option to choose their electricity tariff.
We conducted our data analysis using the Q-method package in R (Zabala 2019). The package uses principal component analysis and we selected a varimax rotation of the factors. We first used the Scree plot in R’s built-in principal component analysis to visualize a discontinuity in the explained variance and determine how many factors to extract using the Q-method package. The package was a user-friendly tool for identifying consensus and controversial statements. The plot feature allowed visualization of the degree of consensus and controversy for each statement.

Moreover, the data for Germany, Sweden, France and Portugal were globally examined with Canonical Correspondence Analysis (CCA) using CANOCO (ter Braak 1986; 1987). CCA is a direct ordination method initially developed to relate multivariate matrices in ecological studies. Its advantages for sociological investigations have been highlighted by Greenacre 2010. In short, CCA directly relates a response variable (e.g. the abundance of species in different sampling sites) with selected explanatory variables (e.g. environmental variables such as temperature, nutrient levels, etc.) measured at the same sites.

In the present study, the response variable included the results of each individual interview (i.e. level of agreement with each statement from 1/highest disagreement to 9/highest agreement), whereas the explanatory variables included the following: individual age, gender, level of
education, country, hydropower knowledge (according to their own rating) and purchase of green electricity.

The analysis generates a diagram that displays approximate values of the weighted averages of each statement (from statement S1 to S25) with respect to the supplied explanatory variables.

4. Results

The statistical analysis of the Q-sorts showed that a number of similar opinion patterns exist in each case study region. This allowed us to group the respondents into different types of perspectives or “world views”. Each perspective represents a different opinion, characterised by similar values and perceptions. In the following, we present different perspectives for each case study region.

4.2 Results from Toulouse, France

From the survey conducted in Toulouse, France, a total of 46 respondents were included in the analysis. Originally, 50 respondents were surveyed but some were removed, as they had lost their motivation during the sorting exercise and gave either incoherent or incomplete responses. Due to an error that occurred in the preparation of the materials, the Q-board was different from that used in the other regions: It had 26 spaces instead of 25 spaces for the 25 statements. The spare space was in the neutral (middle) row. This allowed participants to choose a free space.² We believe that this does not greatly affect the results as most of the analysis is based on the statements they most strongly agree with (the top three statements) as opposed to the statements they most strongly disagree with (the bottom three statements).

Three factors were extracted, which account for approximately 49% of the total variance in the sample (see Table 4). The three factors represent different perspectives on hydropower: (i) fight climate change (ii) promote local well-being and (iii) promote fish-friendly and locally owned hydropower.

² To track how this affected the results from France, we counted where participants placed the free space. Of the 50 participants, one sorting was incomplete, three left the space in the top four rows, 16 left the free space in the neutral row and 30 left the space in the bottom four rows. For the 16 that placed the free space in the neutral row, this had no effect on the results. For the 30 Q-sorts with a free space in the bottom four rows, this means that a neutral statement was shifted down to a (more) negative ranking.
Table 4: Overview of factors for Toulouse

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of loading Q-sorts</td>
<td>17</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Main Themes</td>
<td>Flexibility, climate change, storage</td>
<td>Public participation, job creation, low electricity prices</td>
<td>Fish-friendliness, ownership</td>
</tr>
</tbody>
</table>

Respondents linked to the perspective “fight climate change” can be described as proponents of hydropower operation and expansion. In their view, hydropower as a clean energy source is an important means to reduce greenhouse gas emissions and thereby combat climate change. This group of respondents particularly values that hydropower is a flexible energy source and that it enables energy storage. In that way, hydropower is perceived as a key technology for the transition to a climate friendly energy system, as it can compensate for the fluctuating supply of other renewable energies. This is illustrated by the following quotes:

- “Today it is a big problem that we cannot store energy. Hydropower allows to modulate. It is useless to produce [energy] when it is not needed.” (respondent T17)
- “Hydropower allows to adapt the production to the consumption. It is better to store water and to turbine it when needed.” (T15)
- “It is better to regulate energy production with water than with coal. And it is possible to plan the resource.” (T12)

Furthermore, respondents linked to this perspective do not believe that hydropower production affects tourism or drinking water quality in a negative way. Also, they do not feel that hydropower disturbs the natural scenery and they do not object to living near a hydropower plant. Overall, this can be interpreted as a high acceptance for this type of energy.

For the respondents linked to the perspective “promote local well-being”, it is important that hydropower brings economic benefits for the local population, such as jobs created in the region and low electricity prices. In line with this, respondents in this group want to be able to participate in decisions regarding hydropower development in their community. To illustrate that, respondent T27 pointed out that “the local population is always concerned by the benefits and the eventual consequences of the project.” Similarly, respondent T10 argued that as the local populations are impacted most by hydropower production, they should have a voice in the project planning. Moreover, respondents in this perspective value that hydropower allows their country to reduce energy imports, and that it provides flood protection. They do not see any negative effects of hydropower production on tourism, agriculture or forestry. Interestingly, respondents in this group strongly disagree with the view that France should financially support the expansion of hydropower. One respondent justified this view as follows: “It is better to maintain than to build [new hydropower plants]. There is a lot of other renewable energy to encourage” (T25). In contrast to the first perspective, respondents associated with the perspective “promote local well-being” are rather indifferent towards hydropower’s role as a
climate-friendly energy source. Overall, in this perspective hydropower seems to be accepted as long as certain conditions are met.

In the third perspective, “promote fish-friendly and state-owned hydropower”, the main priority is to make sure hydropower production does not harm fish. In addition, respondents linked to this perspective oppose foreign ownership of hydropower plants and clearly prefer state ownership. As reasons for this, respondents expressed a concern that private companies – particularly when they are based in other countries – are focused on making profits and tend to neglect the common good. For example, one respondent argued that private companies “don’t have any interest in reducing the environmental impacts” of hydropower production (respondent T5). Another respondent (T8) was concerned that foreign operators might pay less attention to security aspects. Similar to the perspective “fight climate change”, respondents do not oppose to living near a hydropower plant. They are not concerned that hydropower could negatively affect tourism, agriculture and forestry or the quality of drinking water.

The three perspectives described above show that views among the local residents in Toulouse differ regarding a number of aspects. Figure 12 shows the ranking of statements from most controversial (top) to least controversial (bottom) between the three perspectives (=factors).

![Figure 12: Ranking of statements in Toulouse from most controversial (top) to least controversial (bottom) between the three perspectives. Factor 1 (red dot) = (i) fight climate change, Factor 2 (green triangle) = (ii) promote local well-being and Factor 3 (blue square) = (iii) promote fish-friendly and locally owned hydropower.](image)

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In Figure 12, each perspective is represented by a different factor. In this case, Factor 1 is a red circle, Factor 2 is a green triangle and Factor 3 is a blue square. On the y-axis, the statements are ranked based on how much the three groups disagree or agree on the statement. Statements with the highest disagreement are at the top and statements with the most agreement are at the bottom. The degree of consensus and disagreement is also represented horizontally. The circle, triangle and square are farthest apart at the top and most closely together at the bottom. The shape is filled in if the statement’s z-score is absolutely different from the other factors, meaning that the difference between their respective z-scores is statistically (p-value<0.05) larger than the standard error of differences.

In the French sample, the most controversial statements were related to citizen participation in the planning of the hydropower plant (statement 17), subsidies (statement 21), flexibility (statement 24), energy prices (statement 4) and recreational opportunities (statement 6).

While citizen participation was ranked highest by respondents in perspective ii (promote local well-being), respondents of the other two perspectives saw citizen participation rather critically. For example, respondent T14 stated that “hydropower is for everyone and it is not in the centre of a city.”

The analysis also allowed us to identify several points of agreement across the three perspectives. Among the case study respondents in Toulouse, there was wide agreement that hydropower does not affect the quality of drinking water, nor does it impede tourism. Regarding tourism, a number of respondents even stated that the opposite is the case, i.e. hydropower can have a positive effect on tourism. For example, respondent T19 argued: “Dams are architectural places, and visiting the infrastructure appeals to people.” Similarly, Respondent T17 stated that the “exhibition [of hydropower] can be interesting.” Moreover, the greatest consensus was a shared indifference regarding profit-sharing with local municipalities (statement 18). Furthermore, in all perspectives respondents saw the need for energy security (statement 5) and disagreed with being proud of France’s hydropower (statement 11).

4.3 Results from Landshut, Germany

From the survey conducted in Landshut, Germany a total of 59 respondents were included in the analysis. Originally, 85 respondents were surveyed but some were removed due to loss of motivation, incomplete responses or because they did not live within the State of Bavaria. Three factors were extracted, which account for approximately 52% of the total variance in the sample. The three factors represent the perspectives of hydropower to (i) promote sustainable energy policy (ii) preserve rivers, fight climate change and keep it local (iii) fish protection first. These results are shown in Table 5.
Table 5: Overview of factors for Landshut

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of loading Q-</td>
<td>28</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>sorts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of</td>
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<td>14.87</td>
<td>12.04</td>
</tr>
<tr>
<td>Explained Variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Themes</td>
<td>Energy storage,</td>
<td>Free-flowing</td>
<td>Fish, flooding,</td>
</tr>
<tr>
<td></td>
<td>imports, policy</td>
<td>rivers, climate</td>
<td>storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>change, ownership</td>
<td></td>
</tr>
</tbody>
</table>

Respondents linked to the perspective “promote sustainable energy policy” demonstrated a clear positive attitude towards hydropower. What they appreciate most about hydropower is that it enables energy storage and that it allows Germany to reduce energy imports. Moreover, respondents in this group believe that the state should support the further expansion of hydropower in Germany. Respondents do not see any considerable negative effects related to hydropower: they do not think that it disturbs the natural scenery and they are not concerned about accidents, negative effects on tourism or disruption of natural habitats. Overall, the perspective can be described as hydropower supporters. This is well illustrated by the following quotes:

- “Water is always available, it isn't polluting and it makes no noise. Water should be used!” (L80)
- “Landshut has a hydropower plant and I am very proud.” (L62)
- “I think more hydropower plants could be built.” (L58)

The perspective “preserve rivers, fight climate change and keep it local” represents a more critical view. Respondents linked to this perspective express a strong preference for free-flowing rivers, while the second most important aspect to them is that hydropower mitigates climate change. Their ranking suggests that they accept and support hydropower as long as it does not considerably harm the river ecosystem. The following quotations underline the priority given to nature conservation:

- “Habitats should not be destroyed.” (L7)
- “It's not worth it when habitats are affected.” (L30)
- “Nature should remain preserved.” (L59 and L86)

Respondents in this group also expressed a high acceptance of river restoration projects. For example, respondent L30 stated: “Renaturation is good. Fish ladders are okay.” Another respondent (L64) argued that it is important for wildlife that rivers can meander and build small tributaries with low flow velocity and backwater pools. A further important aspect in this perspective is ownership of hydropower plants. Respondents are concerned that foreign companies are only interested in making profits, not in preserving resources and the well-being of local residents. Many respondents thus prefer state ownership. For example, respondent L10 stated that “power from water is a public good and when it is privatized, everything is worse. We have no influence anymore and the region should be able to have an influence.”
For respondents linked to the perspective “fish protection first”, hydropower needs to be fish-friendly. For example, one respondent argued that “animals and plants need freedom. There should be free space for animals” (L74). Another respondent argued that a fish-friendly design of hydropower plants was “easy to implement” (L66). Next to that, respondents appreciate that hydropower offers flood protection and enables energy storage. Low energy prices are also important to respondents. In contrast to perspective ii, respondents do not see foreign ownership of hydropower plants critically.

In all three perspectives, the locals we interviewed ranked several statements in a similar way, indicating agreement on the following issues: hydropower does not negatively affect drinking water quality or tourism; concern about accidents is low. This is shown in Figure 13, which presents the least controversial statements in the bottom rows. The top rows of the figure show the most controversial issues in the Landshut case study, i.e. foreign ownership (statement 19), the importance of low electricity price (statement 4), the impact on ecosystems (statement 14), and the impact on the natural scenery (statement 13).

Another particularity of the Landshut case study is that across the three perspectives, people’s (often negative) attitude on nuclear power influenced their perception of hydropower. The nuclear power plant Isar II is located 14 km downstream from Landshut. Several respondents mentioned nuclear power during the interviews and compared it to hydropower. For example, respondent L14 stated: “I don’t believe [hydropower] has an impact on tourism. Nuclear power even warms the water. I don’t know that much about hydropower but it cannot be worse.” Regarding impacts on the natural scenery, participant L21 argued the following: “Is a hydropower plant more beautiful than a nuclear plant? No. But is it better? Yes.” And finally, respondent L23 explained: “I don't think it's a problem to live near a hydropower plant. Nuclear is worse.”
Figure 13: Ranking of statements in Landshut from most controversial (top) to least controversial (bottom) between the three perspectives. Factor 1 (red dot) = (i) promote sustainable energy policy; Factor 2 (green triangle) = (ii) preserve rivers, fight climate change and keep it local; and Factor 3 (blue square) = (iii) fish protection first.

4.4 Results from Örnsköldsvik, Sweden

From the survey conducted in Örnsköldsvik, Sweden, a total of 65 respondents were included in the analysis. Originally, 68 respondents were surveyed but some were removed due to loss of motivation and incomplete responses. Three factors were extracted, which account for approximately 46% of the total variance in the sample. The three factors represent the perspectives of hydropower to (i) fight climate change and create local wellbeing (ii) promote regional ownership and (iii) protect habitats and ecosystems. These results are shown in Table 6.
Table 6: Overview of factors for Örnsköldsvik

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of loading Q-sorts</td>
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<td>15</td>
</tr>
<tr>
<td>Percentage of Explained Variance</td>
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<td>16.75</td>
</tr>
<tr>
<td>Main Themes</td>
<td>Climate change, pride, storage</td>
<td>Profit-sharing, ownership</td>
</tr>
</tbody>
</table>

In the perspective “fight climate change and create local well-being”, respondents generally prioritized abatement of CO₂ emissions and regional economic development over ecological considerations related to the status of the river ecosystem. Respondents generally felt proud of the country’s hydropower sector. Under this perspective, the river is regarded mainly as a production factor that contributes to energy security and economic wellbeing, on the one hand, and to the fight against climate change, on the other hand. The underlying prerogative is, as one respondent expressed it, that there are “plenty of rivers available” in Sweden (Ö54), which should be efficiently used. This view has been expressed in a number of responses:

- “There is no coal and nuclear power, and renewable energy is good.” (Ö11)
- “Climate change should be in focus.” (Ö28)
- “It’s good for the environment does not release as much carbon dioxide as some other energy sources.” (Ö80)
- “In terms of the income of hydroelectric power, the municipalities will receive a share of the profits.” (Ö81)
- “It is important that they create job opportunities.” (Ö60)

For respondents linked to the perspective “promote regional ownership”, the main claim was that the income generated by hydropower producers should stay in Sweden, preferably in the community where the hydropower plant is located. In this context, the issue of foreign ownership was of importance to many of the respondents:

- “Money and jobs should stay in Sweden.” (Ö38; Ö89)
- “It is important for Sweden that the municipalities should own the hydroelectric power plants. And that no foreign company should own these companies.” (Ö55)

Under this perspective, hydropower was generally regarded positively. Some respondents acknowledged negative impacts on river ecosystems and fish populations and argued for a balanced development of the hydropower sector. Overall, however, respondents saw the hydropower sectors adding to economic wellbeing in Sweden (jobs and income). In this context, however, a majority felt that local communities should receive a bigger share of the income.

Respondents linked to the perspective “protect habitats and ecosystems”, focused on the detrimental effects which hydropower installations might have on river ecosystems. Their main concern was that aquatic life was threatened by dams and altered river flows. Another important aspect was the landscape impact of hydropower plants; in this context respondents also stated
that recreational opportunities on rivers (e.g. fishing, bathing, boating, going for a walk) are of importance to them, thereby indicating that hydropower installation and altered river systems might reduce such opportunities. These views are exemplified by the following statements:

- “It is important that the rivers should be free from settlements [buildings].” (Ö3)
- “Rivers without hydropower are beautiful.” (Ö24)
- “Hydropower damages the environment.” (Ö27)
- “Hydropower plants stop the natural path of the fish.” (Ö46)

Respondents in this group also argued that no additional hydropower plants should be constructed in order to preserve the remaining (free-flowing) rivers. Like respondents in perspective ii, respondents in perspective iii were little concerned that hydropower would affect local tourism negatively. However, they felt that free-flowing rivers could promote ecotourism, which “is important for economic growth in the North of the country” (Ö32). While generally concerned about the detrimental impacts of hydropower on the river ecology, some respondents acknowledged the importance of hydropower in the Swedish context and that, in comparison to other technologies, hydropower should be considered an environmental-friendly source of energy.

Figure 14 shows the ranking of statements from most controversial (top) to least controversial (bottom) between the three factors. In the Swedish sample, the most controversial statements were related to the ideal of free-flowing rivers (statement 12), foreign ownership (statement 20), pride in the country’s hydropower (statement 11), profit-sharing (statement 18) and the importance of recreational opportunities on rivers (statement 6). There was the greatest consensus that they do not mind living near a hydropower plant (statement 10) and that hydropower does not have negative effects on tourism (statement 2), agriculture/forestry (statement 3) or the quality of drinking water (statement 8).
4.4 Results from Vila Real, Portugal

From the survey conducted in Vila Real, Portugal, a total of 87 respondents were included in the analysis. Originally, 103 respondents were surveyed but some were removed due to loss of motivation, incomplete or illogical responses or because they live outside the case study district. Three factors were extracted, which account for approximately 40% of the total variance in the sample. The three factors represent the perspectives of hydropower to (i) fight climate change and create local well-being; (ii) promote regional ownership and modernization; and (iii) protect habitats and ecosystems. These results are shown in Table 7.
In the perspective “fight climate change and create local well-being”, the most important attribute of hydropower is that it contributes to climate change mitigation. Respondents linked to this perspective see the current abundant use of fossil energies critically and prefer renewable energies. They support the use of hydropower, which they perceive as a clean and environmentally-friendly energy source. This is well illustrated by the following quotes:

- “It is extremely important to have renewable energy sources to reduce the dependence on fossil fuels and to mitigate climate change.” (V101)
- “Hydropower helps in reducing CO₂ emissions. It is a renewable source and the water used is returned to the river. Fossil energies are limited and generate pollution.” (V124)

In particular, respondents in this group value that hydropower allows storing energy. At the same time, it is important to them that hydropower generates economic benefits for the local population, such as creating jobs and keeping electricity prices low. Regarding job creation, it was said during the interviews that jobs in the region are sparse and particularly needed for the younger population. Regarding electricity prices, in the view of a number of respondents in this group the current price level is too high. Moreover, in this perspective, living close to a hydropower plant is not seen as problematic and no negative effects of hydropower production on tourism are perceived. Respondents linked to this perspective do not believe that the state should own hydropower plants. They argue that the State’s role should be to regulate water bodies and implement adequate legislation, but not necessarily to own and run hydropower plants. In addition, respondents believe that private investments are necessary to make optimal use of hydropower. For example, one respondent argued that “society cannot be totally dependent on the State. The State should only legislate” (V 134). Similarly, another respondent stated that “the State should have other duties. It should directly manage water and other common goods, but not energy” (V 82). Also, respondents in this group oppose the idea that citizens should have a veto right against the construction of hydropower plants. Finally, they do not have a problem with foreign companies owning and running hydropower plants in their region.

For respondents linked to the perspective “promote regional ownership and modernization”, the central question regarding hydropower is who owns the production plants. While in general respondents in this group have a positive attitude on hydropower, they are firmly opposed to foreign ownership of hydropower facilities and prefer state ownership over private companies.

### Table 7: Overview of factors for Vila Real

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of loading Q-sorts</td>
<td>32</td>
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</tr>
<tr>
<td>Percentage of Explained Variance</td>
<td>18.048</td>
<td>11.46</td>
</tr>
<tr>
<td>Main Themes</td>
<td>Climate change, job creation, storage</td>
<td>Ownership, modernization</td>
</tr>
</tbody>
</table>

In the perspective “fight climate change and create local well-being”, the most important attribute of hydropower is that it contributes to climate change mitigation. Respondents linked to this perspective see the current abundant use of fossil energies critically and prefer renewable energies. They support the use of hydropower, which they perceive as a clean and environmentally-friendly energy source. This is well illustrated by the following quotes:

- “It is extremely important to have renewable energy sources to reduce the dependence on fossil fuels and to mitigate climate change.” (V101)
- “Hydropower helps in reducing CO₂ emissions. It is a renewable source and the water used is returned to the river. Fossil energies are limited and generate pollution.” (V124)

In particular, respondents in this group value that hydropower allows storing energy. At the same time, it is important to them that hydropower generates economic benefits for the local population, such as creating jobs and keeping electricity prices low. Regarding job creation, it was said during the interviews that jobs in the region are sparse and particularly needed for the younger population. Regarding electricity prices, in the view of a number of respondents in this group the current price level is too high. Moreover, in this perspective, living close to a hydropower plant is not seen as problematic and no negative effects of hydropower production on tourism are perceived. Respondents linked to this perspective do not believe that the state should own hydropower plants. They argue that the State’s role should be to regulate water bodies and implement adequate legislation, but not necessarily to own and run hydropower plants. In addition, respondents believe that private investments are necessary to make optimal use of hydropower. For example, one respondent argued that “society cannot be totally dependent on the State. The State should only legislate” (V 134). Similarly, another respondent stated that “the State should have other duties. It should directly manage water and other common goods, but not energy” (V 82). Also, respondents in this group oppose the idea that citizens should have a veto right against the construction of hydropower plants. Finally, they do not have a problem with foreign companies owning and running hydropower plants in their region.

For respondents linked to the perspective “promote regional ownership and modernization”, the central question regarding hydropower is who owns the production plants. While in general respondents in this group have a positive attitude on hydropower, they are firmly opposed to foreign ownership of hydropower facilities and prefer state ownership over private companies.
As reasons for this, respondents indicated a concern that the Portuguese population would not benefit from hydropower if private and particularly foreign companies were in charge of them. This is illustrated by the following statements of respondents:

- “Because it is our energy source and the Portuguese should have all the benefits, including financial ones.” (V32)
- “The resource is here. It is a matter of social justice to benefit the locals with the benefits of hydropower.” (V41)
- “Since energy is needed by all citizens, it should be owned by the State.” (V59)
- “The country’s energy should be independent of foreign interests.” (V64)

Furthermore, respondents in this group prefer the modernization of existing hydropower plants over the construction of new plants. They are not concerned about accidents linked to hydropower production or about negative effects on tourism, and they do not mind living near a hydropower plant. Similar to perspective i, they do not think that citizens should have a veto right against the construction of hydropower plants.

Respondents linked to the perspective “protect habitats and ecosystems” expressed a rather critical view on hydropower. Their major concern is about ecological effects such as the destruction of natural habitats and harming fish populations. In addition, they are concerned about negative impacts on agriculture and forestry. Respondents particularly see large hydropower projects critically. For example, one respondent mentioned the “damage caused by large dams in rivers such as the Tua, Sabor and Tâmega” (V109), and another respondent stated: “I care about habitats and animals when they are in danger or when the intervention is large” (V111). Flood protection is a central issue in this perspective, as “floods cause many damages and are increasingly common” (V50). Moreover, respondents in this group tend to prefer other renewable energies over hydropower, as they believe that for example, solar energy has less harmful impacts on the environment. They do not feel proud of Portugal’s hydropower. In contrast to perspective ii, respondents in this group do not believe that the State should own hydropower plants.

Figure 15 shows the ranking of statements from most controversial (top) to least controversial (bottom) between the three factors. In the Portuguese sample, the most controversial statements were related to state ownership (statement 20), concern about accidents related to hydropower plants (statement 9), foreign ownership (statement 19), the impact on the natural habitats (statement 14) and financial support for hydropower (statement 21). There was the greatest consensus that low electricity prices are important (statement 4), rivers are not meant to flow freely (statement 12), hydropower does not have a negative impact on natural scenery (statement 13) or recreational opportunities (statement 6) and energy security is important (statement 5).
Figure 15: Ranking of statements in Vila Real from most controversial (top) to least controversial (bottom) between the three perspectives. Factor 1 (red dot) = (i) fight climate change and create local wellbeing; Factor 2 (green triangle) = (ii) promote regional ownership and modernization; and Factor 3 (blue square) = (iii) protect habitats and ecosystems.

4.5 CCA results

Figure 16 presents the diagram (biplot) depicting the CCA results and Table 8 shows its main results. The analysis was statistically significant (as shown by a Monte Carlo simulation test with 1000 permutations for both the first axis eigenvalue and trace, terBraak 1987) and explained 12.6% of the total variation in the degree of agreement/disagreement among different interviewees.

Although the explanatory variables used were not successful in explaining a considerable part of the variation among interviews, some differences were clearly highlighted by the analysis. The country where the interview took place was the main explanatory factor related to the global differences in agreement for the 25 statements.
From the biplot (Figure 16) it is possible to see that the average level of agreement for the statements varied among the four case studies, particularly between a) Portugal, b) France and c) Sweden/Germany (Table 9).

Note that statements placed near the center of the biplot, such as statement 21, have similar levels of average agreement according to the explanatory variables, whereas the opposite occurs for statements placed far from the biplot center.

For example, in the French case study, the level of agreement for statements 2, 10 and 17 was higher, and that for statements 1, 5, 15 and 16 was lower than in any other case study. For Vila Real in Portugal, the level of agreement for statements 4 and 14 was higher, and that for statements 20 and 22 was lower when compared with the level of agreement for the same statements in the other case study countries. Average levels of agreement for the 25 statements were usually more similar between Sweden and Germany than between those countries and France and Portugal. The level of agreement in Sweden and Germany for statements 11, 16, 19, 20 and 22 was higher, and that for statements 3, 8 and 9 was lower when compared with the levels of agreement for the same statements in France and Portugal.

The respondent’s age was also an important explanatory variable in the CCA, with the degree of agreement changing with age (Table 10). For example the level of agreement increased with age for statements 20 and 22, whereas the opposite occurred for statement 14.

Table 8: Summary statistics for the CCA relating the degree of agreement/disagreement in relation to statements about hydropower to explanatory variables. The trace (i.e. the sum of the total eigenvalues of a Canonical Correspondence Analysis of the statements) = 0.143.

<table>
<thead>
<tr>
<th></th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Total (all axis)</th>
</tr>
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<tr>
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<td>0.004</td>
<td>0.018</td>
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<tr>
<td>Statements agreement-explanatory variables correlations</td>
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<td></td>
</tr>
<tr>
<td>Cumulative percentage variance of statements agreement (%)</td>
<td>5.8</td>
<td>2.9</td>
<td>12.6</td>
</tr>
</tbody>
</table>
**Figure 16**: Axis one and two of CCA biplot for the 25 statements (S1 to S25, see Table 2) and explanatory variables assessed in individual interviews conducted in Germany, Sweden, France and Portugal. The weighted averages of each statement agreement are represented by blue triangles. The continuous explanatory variables are represented by red arrows, that roughly point in the factor direction of maximum variation, whereas categorical variables are represented by the variable label. Each interviewee is also depicted in the diagram by a grey dot.

**Table 9** Average agreement (from 1/highest disagreement to 9/highest agreement) for each of the 25 statements (from S1 to S25) in each case study country.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Portugal</th>
<th>France</th>
<th>Sweden</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>5.66</td>
<td>3.91</td>
<td>5.31</td>
<td>5.14</td>
</tr>
<tr>
<td>S2</td>
<td>3.34</td>
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<td>3.20</td>
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<td>S3</td>
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<td>26-44 years</td>
<td>45-64 years</td>
<td>≥65 years</td>
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<td>4.70</td>
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<td>5.34</td>
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<td>3.68</td>
<td>3.13</td>
<td>3.85</td>
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<td>4.30</td>
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<td>S16</td>
<td>5.79</td>
<td>5.91</td>
<td>5.66</td>
<td>5.29</td>
</tr>
<tr>
<td>S17</td>
<td>6.19</td>
<td>5.72</td>
<td>5.24</td>
<td>5.66</td>
</tr>
<tr>
<td>S18</td>
<td>4.16</td>
<td>4.75</td>
<td>4.58</td>
<td>3.90</td>
</tr>
<tr>
<td>S19</td>
<td>4.53</td>
<td>5.16</td>
<td>5.86</td>
<td>5.80</td>
</tr>
<tr>
<td>S20</td>
<td>5.21</td>
<td>5.82</td>
<td>5.52</td>
<td>4.93</td>
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<tr>
<td>S21</td>
<td>4.42</td>
<td>4.93</td>
<td>5.49</td>
<td>5.22</td>
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<tr>
<td>S22</td>
<td>5.91</td>
<td>5.33</td>
<td>5.35</td>
<td>5.59</td>
</tr>
<tr>
<td>S23</td>
<td>4.51</td>
<td>4.68</td>
<td>4.73</td>
<td>5.51</td>
</tr>
<tr>
<td>S24</td>
<td>4.89</td>
<td>5.79</td>
<td>5.75</td>
<td>5.98</td>
</tr>
<tr>
<td>S25</td>
<td>6.04</td>
<td>5.52</td>
<td>5.58</td>
<td>5.80</td>
</tr>
</tbody>
</table>

Table 10: Average agreement (from 1/highest disagreement to 9/highest agreement) for each of the 25 statements (from S1 to S25) according to age.
5. Discussion

5.1 Discussion of the results

Our analysis shows that diverse views on hydropower exist among residents living in the four hydropower areas. For each case study area, we identified three different perspectives on hydropower, which represent different opinions. The comparison of the results reveals overlaps and similar perspectives across the case study areas. These encompass the following:

1) **Climate protection as a central issue:** In all four case study towns we found groups of respondents who support hydropower because it helps fighting climate change. They see an urgent need to address the climate crisis and perceive hydropower as a good means to contribute to this. Hence, hydropower is viewed very positively. In the perception of these groups, hydropower is not only a climate-friendly energy, but also a key technology for a renewable energy system, as it offers system flexibility through its potential to store energy. This perception is most pronounced in perspective (i) of both Vila Real and Örnsköldsvik, where fighting climate change was the top priority. It is also present in perspective (ii) of Landshut and perspective (i) of Toulouse, where climate change mitigation was second-ranked. Often in these groups negative ecological impacts are accepted or not noticed. An exception is perspective (ii) in Landshut, which demands that hydropower is both climate- and ecosystem-friendly.

2) **Concern about ecological effects:** In all four case study towns, respondents expressed concerns about negative ecological impacts of hydropower, such as harming fishes, habitats, or the river ecosystem. Such concerns dominate perspectives (iii) in both Örnsköldsvik and Vila Real. They are also part of the perspectives (iii) in Toulouse as well as of perspectives (ii) and (iii) in Landshut. The perception of ecological impacts is, in fact, the main reason for a number of respondents to take on a negative stance towards hydropower.

3) **Focus on local benefits:** A further frequent pattern of opinion was that local hydropower plants should first and foremost bring benefits to the region. In particular, job creation, low electricity prices and flood protection are important to the respondents. Their perception of hydropower hence appears to be centred on aspects that affect them (or their close surroundings) directly. Locals who take on this view generally have a positive attitude towards hydropower if their region benefits from it. This view is often linked to strong opinions on ownership questions (see below).

4) **Plant ownership as a central issue:** In all four case studies, we found groups with the opinion that hydropower plants should be operated by companies based in the country, and who preferred state-run plants over private ones. Respondents who take on this view often expressed the concern that all financial benefits of producing water power are taken away from the region, that foreign or big transnational companies are too much focused on profits and neglect the local well-being, or that the state or region loses influence over its water resources. This opinion was present in perspective (ii) in Landshut, Örnsköldsvik and Vila Real and perspective (iii) in Toulouse.
Points of controversy across case study regions

Overall, our study results show that hydropower production is not a highly contested topic for the local residents of the four case study regions. However, within the perspectives that we identified, conflicting views exist on a number of issues, namely ecological effects, ownership questions and changes in electricity prices. Certain groups within the local populations have very strong opinions regarding these issues. These points of criticism may drive public debates on hydropower and influence public acceptance. Therefore we believe that it is useful for hydropower operators, planners as well as politicians to be aware of these issues and consider them in their decisions. For example, regarding ownership of plants, our results hint to a preference for local hydropower operators, while big multinational companies based in other countries were rather seen critically. Here, it seems advisable for hydropower companies to initiate dialogues with residents. In addition, marketing strategies could highlight benefits of hydropower production for the region. Moreover, certain groups in all of the four case study towns expressed a strong preference for low electricity prices (while certain groups actually said they would accept higher prices or are indifferent on the subject as long as hydropower is eco-friendly or climate-friendly). The hydropower sector should be aware that announcing mitigation measures or restoration project could raise fears of price rises. The public should hence be prepared, adequately informed about benefits of such measures and costs should be made transparent. The most controversial topic and main point of criticism in all four case study areas was the perceived negative impact of hydropower on fish populations, natural habitats and natural river functions. We will, therefore, discuss this in more detail in the following.

While not all respondents were aware of ecological impacts and others found them acceptable, a number of respondents expressed great concern. In some cases, concerns about the environmental impact even led to a rejection of hydropower, as the following quotes illustrate:

- “Hydropower plants disturb. There are other ways of producing electricity and hydropower represents a small proportion of the electricity produced.” (V2)
- “The impact on landscapes of big and little dams is huge – for example in mountains.” (T18)
- “Hydropower damages the environment. You should keep water natural.” (Ö 27)

While only a small fraction of participants in our survey have expressed a negative attitude towards hydropower, this shows that ecological concerns have the potential to cause resistance.

Other acceptance studies in Europe had similar findings. In a case study on the local level in Greece, researchers revealed that a small minority strongly opposes to the use of small hydropower in the region due to concerns about negative environmental impacts (Malesios and Arabatzis 2010). Botelho et al. (2016) came to a similar conclusion in their Portuguese acceptance study. The authors state that a small, but not a trivial fraction of 9.2% of their respondents think that hydropower is not environment-friendly.

Moreover, resistance against renewable energies was generally found to be most likely to come up when large projects are planned to be built (Schumacher et al. 2019). Regarding hydropower in Norway, Bakken et al. (2012) had observed “a tendency in the public opinion that 'small-scale hydropower is considered green and beautiful', while large-scale hydropower
projects have a reputation to cause dramatic and negative impacts to the environment” (p. 186). We found that particularly in Vila Real, residents had a similar, critical perception of large-scale hydropower projects. For example, respondent V35 stated: “I dislike large transformations linked with large dams, such as Miranda do Douro and Alqueva reservoirs.” Likewise, respondent V109 prioritized free-flowing rivers “because of the damage caused by large dams in rivers such as the Tua, Sabor and Tâmega.” Furthermore, a respondent in Vila Real stated that he cannot be proud about Portugal’s hydropower, “because a large dam nearby (Foz Tua) destroyed a natural river and its ecosystems” (V 2). In the Portuguese case study we have the effect that the negative perception of large hydropower projects influences people’s overall attitude towards hydropower negatively. This seems to be particularly the case when residents are not able to differentiate between different types of technologies. The self-assessment of our study participants, in fact, showed that knowledge about hydropower is very differently developed. This mirrors the results of other studies, e.g. by Moula et al. (2013), who found that in Finland “in-depth understanding of renewable energy technologies varies markedly” (p. 96). Here, we see a need to better inform the residents in hydropower regions to enhance their acceptance. One of the respondents in Vila Real had a similar request: “Citizens near hydropower plants and dams should be more informed, perhaps by postal mail” (V112).

Providing a good knowledge base has also been a key recommendation in a number of previous acceptance studies in Europe. In Greece, Malesios and Arabatzis (2010) identified a need for additional public information on small hydropower technologies (and particularly its benefits). Ntanos et al. (2018) found that citizens in Nikaia, Greece, were not well informed about hydropower solutions. Similarly, Chiciudean et al. (2018) see a lack of information as one factor hindering the public to support renewable energy solutions such as micro-hydropower in the North-West region of Romania.

**Points of consensus across case study regions**

We would also like to point out that there are a number of topics on which respondents across the four case study towns agree, as also shown by the CCA results. This demonstrates a high acceptance of hydropower in relation to these topics.

First, our results indicate that the local residents in the four case study regions do not have a problem with living close to a hydropower plant. Several respondents stated that they actually do live close to a plant and do not feel disturbed by hydropower production, particularly as the plants emitted little noise. One respondent from Landshut emphasized the preference to live near a hydropower station rather than near a nuclear power plant. This high acceptance of living in the proximity of (small-scale, run-of-the-river) hydropower production sites is in strong contrast to findings on other types of renewable energy sources (e.g. Ellis, Barry, and Robinson 2007; Botelho et al. 2016; Schumacher et al. 2019). We thus find an absence of the so-called NIMBY behaviour, i.e. accepting hydropower as long as it is not located or planned in the own backyard. We believe that this is in part due to the fact that the local populations in the case study towns have had long-time experience with hydropower production, and the technologies are well-known. Other studies have found that knowledge and experience can positively influence the acceptance of energy technologies (Ribeiro et al. 2014; Malesios and Arabatzis 2010; Schumacher et al. 2019).
Next, particularly when it comes to hydropower, trade-offs in the usage of land and water resources are important to discuss. Researchers have been concerned that hydropower has negative impacts on other industries including agriculture, forestry and tourism. In particular, there were concerns that hydropower threatens tourism (Schreurs and Ohlhorst 2015; Barry et al. 2015; Saha and Idsø 2016). Interestingly, our findings show that the majority of local residents in the studied hydropower regions do not believe that hydropower affects tourism in a negative way. In all five identified perspectives and across the three case study regions, respondents disagreed strongly with the statement ‘I am concerned that hydropower negatively affects tourism.’ Exemplifying this view, a local resident of Vila Real noted that “no one stops visiting a place because of hydropower” (V 19).

In fact, many respondents think that hydropower production harmonises with tourism, or that tourism can even benefit from hydropower:

- “It doesn’t affect tourism. It can even be an attraction.” (L 62)
- “I do not think tourism is adversely affected by hydropower, rather on the contrary, it may have been positive.” (Ö 30)
- “There are no negative effects on tourism. Tourism improves maintenance of hydropower plants.” (V13)

Finally, there was also wide agreement that existing hydropower plants should be modernised before new ones are build, and that it is important that hydropower allows the respective states to reduce energy imports.

5.2 Implications for hydropower operators and policymakers

While the results of our analysis illustrate that a range of aspects are of relevance when it comes to the formation of public perceptions regarding hydropower, they show that ecological considerations, particularly with regard to the status of the river ecosystem, often play a key role. Survey respondents often emphasized that they consider mitigation measures to be important in order to preserve fish and the river ecosystem. However, some respondents expressed doubts about whether existing mitigation measures are effective in preserving fish populations, and see a need to improve their design:

- “It does not work well in all cases. It can also damage the fish. But if they developed [mitigation measures] more and make them work, they would be good.” (Ö29)
- Mitigation measures are “very good, if they work.” (L73)
- “[Mitigation measures] should mitigate the impacts completely.” (V121)

A common interest within the group of respondents who prioritized ecological considerations in the context of hydropower generation was to preserve the aquatic environment, river animals and plants. Respondents of this group thought that mitigation measures are important to reduce pressures on aquatic organisms and their habitats. Particularly respondents from Vila Real believed that such measures are currently not widely implemented and that they should be “mandatory in all situations” (V35), while another felt that “They are good in theory, but do not work properly in practice” and that researchers “should develop more within the subject” (Ö7). Looking at the three main categories of ecological restoration measures (cf. Dewitte et al. 2018), Table 11 describes, based on the results of our analysis, which measures can be assumed to be most relevant when it comes to shaping public perceptions of hydropower.
Table 11 Mitigation measures and their relevance for shaping public perceptions of hydropower

<table>
<thead>
<tr>
<th>Category of mitigation measure</th>
<th>Relevance / Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural mitigation measures</td>
<td>Structural measures are likely to be accepted, but it is important to provide information about how they work. For example, locals mentioned that the Maxwehr plant in Landshut had a fish ladder and that they found this positive. However, several said they watched the ladder but never saw any fish, which made the question whether it was working.</td>
</tr>
<tr>
<td>Morphological mitigation measures</td>
<td>Because these types of changes are likely to be most easily observed by the public and generally make a river’s appearance more &quot;natural&quot;, they are likely to be positively perceived.</td>
</tr>
<tr>
<td>Operational mitigation measures</td>
<td>Operational strategies which increase system flexibility are likely to be perceived positively, as long as visible changes (e.g. no water in the river) are not observable.</td>
</tr>
</tbody>
</table>

Addressing the negative ecological effects of hydropower by implementing cost-effective mitigation measures might thus be a means to increase the public acceptance of hydropower schemes. However, while the results of our analysis have shown that ecological restoration measures are generally acknowledged by local citizens, the knowledge about specific mitigation measures among the general public is relatively scarce. Fish ladders can be regarded as the only mitigation measure which is relatively well known among the general public. Additional, more complex mitigation measures are largely unknown and it is difficult to explain how they work to the public.

Public communication and awareness raising campaigns might help to increase public knowledge about the existing spectrum of mitigation measures and their effects on the river ecosystem. The effectiveness of such campaigns might be increased if, besides focusing on specific restoration measures, they also take up more general aspects, e.g. the perception that rivers should ideally flow freely – a statement which many of the survey participants supported. By linking specific restoration measures to a broader narrative, the outreach of communication and awareness raising campaigns might be increased.

Apart from ecological considerations, another aspect that might be taken up in communication and awareness raising campaigns is related to the ownership of the plant and, to a lesser extent, to how the income generated by the plant is distributed. When plants are regionally owned, it may be possible to adopt marketing strategies to increase local support, or even to introduce regional green electricity brands.

3 The latter is for example practiced in some districts in Germany with local wind energy and can help enhancing acceptance for renewable energy projects (Buchmüller 2016).
5.3 Discussion of the method

The applicability of Q-method for studying the public’s perception of hydropower and related mitigation measures is important to discuss. While the method has proven useful in the study of energy technologies, it has had limited application in the public sphere (Buchel and Frantzeskaki 2015; Cools et al. 2009). This is arguably due to the time and intellectual constraints of the interview procedure. As the Q-method interview is conducted in multiple steps with several pre-sorts of statements as well as entry and exit interviews, an individual interview can last hours (Winter, Prozesky, and Esler 2007). To address its time demands, the method usually relies on a small but thoughtfully pre-selected group of participants which reflects the range of stakeholders (Brown 1980). While many q-studies have included members of the public in the p-set as well as policymakers and industry representatives, several members arguably do not represent the greater public. This is particularly evident given the spectrum of perspectives captured in our study of the public across the case study regions. Thus, to balance the time constraints with the desire to study public opinions, we shortened and simplified the statements as well as the exit interview. Furthermore, since participants are required to distinguish between many statements about the same topic, it can be intellectually challenging if they have limited background knowledge. Given the high rates of participation in the public sphere, the Q-method can be feasibly used in future studies of public opinion, particularly when fewer and less complex statements (or even pictures) are used.

There were additional features of our design which may be useful for Q-method practitioners. In other studies (e.g. Raadgever, Mostert, and van de Giesen 2008), online Q sorts have been used to reach a wider audience, allow participants to sort at a convenient time and reduce the time for the analysis. The researcher could thus choose between an in-person, online or digital Q-sort in the field. In our experience, the visual aid was an important feature of our survey design as it attracted the attention of passers-by thereby increasing the response rate. In turn, conducting the interview in-person rather than online improved the quality of interview responses and Q sorts. Second, to facilitate the ease of sorting, a horizontal design of the Q-board was used. While this has no statistical implications, participants found ranking from top (strongly agree) to bottom (strongly disagree) more intuitive rather than from left to right (see Figure 6 in chapter 3.4).
5. Conclusion

The fact that a large part of the existing hydropower plants in Europe have been in operation for many decades and are ready for refurbishment, upgrading and potential expansion requires operators and political decision-makers across Europe to develop efficient, but at the same time also widely accepted designs for optimized hydropower plants. This development falls together with an increased demand for public participation when it comes to the planning and implementation of (renewable) energy projects.

In this study, we explored public opinion on hydropower in four European case study towns. Our analysis has shown that people who live in the surroundings of small-scale run-of-river hydropower plants generally accept hydropower solutions. On the other hand, when looking deeper into the statements made by the survey respondents, the analysis shows that people do partly have strong opinions, e.g. when it comes to the role of hydropower in fighting climate change, ecological effects on the river ecosystems, distributional effects of local hydropower plants, or plant ownership. Thus, the results show that there is room – and potentially the need – for plant operators and political decision-makers at the local level to address a range of public perceptions when it comes to the construction of new or the refurbishment of existing hydropower plants.

Among the survey participants, the environmental effects of hydropower plants have been discussed from two different perspectives. On the one hand, respondents acknowledged the contribution of hydropower to climate change mitigation. On the other hand, respondents were often concerned about the effects which hydropower plants have on the river ecosystem. In this context, respondents were generally aware of the detrimental effects which hydropower plants might have on fish migration, aquatic habitats and river flow.

The design and implementation of ecological mitigation can, therefore, be considered as a means to address public concerns related to the status of the river ecosystem. To this end, operators and political decision-makers will have to develop strategies, which address public concerns by demonstrating how specific mitigation measures can contribute to improving the ecological status of the river ecosystem. Such information and awareness raising campaigns could be a key component of a broader public engagement effort, which aims to involve local citizens in the larger decision-making process around the future design of local hydropower plants with the aim to ensure broad public acceptance of the (refurbished) plant or scheme.

For the Decision Support System (DSS) developed within FIThydro, this implies that DSS Step 4 on "Risk-Based Decision of Scheme Plan OR Prioritised Cost-Efficient Mitigation Plan" could be implemented in a way that it provides room for consulting the general public - in addition to organised stakeholder groups - in order to determine the social acceptance of project proposals that concern the construction of new or the refurbishment of existing schemes. This consultation could take the form of an acceptance analysis like the one presented in this report, but other formats such as focus group meetings or citizen science activities could likewise be suitable means to make the public’s voice heard in the planning and decision-making process.
6. References


Schreurs, Miranda, and Dörte Ohlhorst. 2015. “NIMBY and YIMBY: Movements For and Against Renewables in Germany and the United States.” Nimby Is Beautiful: Cases of Local Activism and Environmental Innovation around the World.


Wolsink, Maarten, and Sylvia Breukers. 2010. “Contrasting the Core Beliefs Regarding the Effective Implementation of Wind Power. An International Study of Stakeholder
