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From Cooling Water War to Cooling Towers: Transnational Water Diplomacy around the Allocation of Nuclear Cooling on the Aare and Rhine Rivers, 1965-1972

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ABSTRACT: This article explores the efforts of Germany and Switzerland, from 1965 to 1972, to mitigate thermal pollution caused by nuclear power plants along the Aare and Rhine Rivers. Despite the initial promise of nuclear energy, concerns about its environmental impact, specifically on water quality, led both countries to collaboratively set temperature limits for cooling water discharge from nuclear power plants. In contrast to the predominant focus on anti-nuclear protests in the existing literature, this article highlights the cooperative aspects of cross-border management, revealing a concerted effort to balance the utilisation of river cooling capacities while safeguarding water quality. The article contributes to the evolving field of water diplomacy, challenging the notion of inevitable conflicts by showcasing a joint approach to addressing shared environmental challenges.

KEYWORDS: Nuclear energy, Rhine River, thermal pollution, water diplomacy, cooling water

INTRODUCTION

After World War II, many European nations saw nuclear energy as a significant opportunity, one that offered affordable electricity and global recognition for industrial and technological advancement. Eager to capitalise on these benefits, they began constructing nuclear power plants, often relying on rivers for cooling. In the late 1950s, the emergence of large-scale nuclear power plants that were similar in design to fossil fuel plants created a substantial demand for cooling water (Smil, 2010).

During the 1960s and 1970s, German and Swiss energy companies explored the feasibility of nuclear power plants equipped with once-through cooling systems, which depended on the abundant waters of the Rhine River. As a transboundary resource, however, the Rhine presented significant challenges, requiring international cooperation to safeguard water quality. The river served multiple roles that made sustainable management crucial, including transportation, waste disposal, industrial use, and recreation. At the time, international law offered little guidance on transboundary water sharing, necessitating case-by-case negotiations (Wolf, 1999). Also, political tensions were heightened by a combination of power imbalances between upstream and downstream regions and conflicting national priorities.

The multilevel nature of negotiations between Switzerland and Germany added to their complexity. Besides federal governments, both nations have state-level governments, called *Bundesländer* in Germany and cantons in Switzerland. For Germany, the state of Baden-Württemberg represented the Federal Republic in talks, engaging with various Swiss federal departments and cantons. Matters were further complicated by historical agreements between Baden and Switzerland that regulated Rhine installations but not water withdrawals. Unlike earlier treaties focused on hydropower and water flow,

the substantial cooling demands of nuclear power plants marked a pivotal shift in river management priorities (Aargauischer Wasserwirtschafts-Verband, 1966).

Despite ambitious nuclear plans on both sides, coordination between Germany and Switzerland was limited, raising concerns among experts and environmentalists about potential thermal pollution. Key areas of focus included the Aare River, Switzerland's most water-rich tributary of the Rhine, and the High Rhine, the section between Lake Constance and Basel. Although initial assessments acknowledged the limited thermal capacity of these rivers, comprehensive studies on the environmental impact of nuclear power plants lagged behind. To address these uncertainties, Baden-Württemberg and Switzerland initiated negotiations in 1967 that aimed to allocate cooling water fairly and advance environmental research. Both parties feared that unchecked warming of the Rhine could reduce oxygen levels and compromise its assimilative capacity, transforming the river into a polluted waterway[1] (*Der Spiegel*, 1970, 1975).

Figure 1. Map of Switzerland, Germany and France with the active, inactive, uncompleted and planned nuclear power plants on the Aare and High Rhine Rivers

Source: Red Geographics.

[1] A body of water can only absorb a limited amount of pollution without a decline in the water quality; in hydrology this is referred to as maximum assimilative capacity (Hashemi Monfared et al., 2017).

By 1967, several Swiss nuclear power plants were under construction, including Beznau I and Mühleberg, with others in the planning stages, such as Beznau II, Kaiseraugst and Leibstadt. Meanwhile, Germany, though lacking active construction projects, had ambitious plans for nuclear facilities along the High Rhine. This competition for limited cooling water sparked tensions between the two nations and within each country as Swiss cantons and German states vied for access.

This article examines the early development of nuclear energy along the Aare and High Rhine Rivers, focusing on the negotiations between Switzerland and Baden-Württemberg from 1965 to 1972. It situates these events within the analytical frameworks of water diplomacy, transboundary water interaction, and multilevel governance. During the negotiations, additional studies were conducted on the thermal capacity of the Aare and Rhine Rivers. These investigations revealed that the ambitious nuclear expansion plans were overly optimistic, as not all proposed facilities could operate with once-through cooling. In response, Switzerland banned once-through cooling systems on the Rhine in 1971, a decision Germany followed in 1972 (Genscher, 1972).

BACKGROUND: COOLING OF NUCLEAR POWER PLANTS AND EXCESS HEAT

Nuclear power plants convert only a portion of the energy they generate into electricity, with the rest – approximately two-thirds – released into the environment as waste heat. Cooling nuclear power plants is crucial to the prevention of reactor overheating and potential meltdown, particularly with the prevalence of light-water reactors, the most common nuclear power plant type. Cooling methods and thermal efficiency discussions primarily revolve around this technology. Various cooling technologies exist. Once-through cooling draws water from rivers, lakes or the sea and then discharges it back into the environment at a higher temperature. While it requires significant water quantities, evaporation is minimal, yielding high thermal efficiency. Closed systems, such as those with cooling towers, use less water but have higher evaporation rates and lower thermal efficiency. Dry cooling systems, which employ air, are less efficient and more expensive (Anderson, 2013).

Waste heat, also termed thermal or heat pollution, affects bodies of water in various ways; it alters their physical, chemical and biological properties and complicates water quality maintenance. Elevated temperatures can deplete oxygen levels, harming fish populations and disrupting aquatic ecosystems. Water bodies become less resilient, with increased temperatures favouring certain organisms, often leading to decreased water quality and ecosystem imbalance (Regierungsrat Basel-Stadt, 1966; Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1969a; Wyss, 1970). The definition of pollution that is applied here follows that laid down in the EU Water Framework Directive. It states that pollution is, "the direct or indirect introduction (…) of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems" (European Parliament and European Council, 2000).

Returned cooling water further impacts downstream river cooling capacity, which in turn affects downstream nuclear power plants. Research on the effects of thermal power plants on water bodies began in the 1950s in the USA and the UK (Walker, 1989). By the 1960s, as Germany and Switzerland considered commercial nuclear power plants, it became imperative to understand the rivers' thermal capacities and negotiate cooling water rights, especially given the Rhine River's existing pollution levels and limited cooling resources. Assessing thermal load relative to planned nuclear power plant capacities became essential to prevent further degradation of water quality and ensure sustainable resource management.

CONCEPTUAL APPROACH: HISTORICAL WATER AND NUCLEAR DIPLOMACY IN A TRANSBOUNDARY CONTEXT

The article contributes to several areas of water and nuclear history research that have received little attention to date. As far as transnational historiography is concerned, the focus has been strongly on the

anti-nuclear movement.[2] In these works it is often emphasised how social movements formed and collaborated across borders (Kalmbach, 2017; Kaijser and Meyer, 2018). This focus also led to the impression that nuclear energy received little support from the West German population from the mid-1970s onwards (Brünig, 2021). Furthermore, energy history, and nuclear energy history in particular, continues to be analysed on a national rather than a transnational level (Kalmbach, 2017; Lindström et al., 2021).[3] Occasionally, the competition between two countries is undertaken as a topic, but there is still hardly any historical research in the field of cross-border cooperation (Lagendijk, 2016).[4] Finally, the fundamental role of water in nuclear energy has often been overlooked, despite the fact that nuclear risk perception in the 1950s and 1960s was strongly water-related (Högselius, 2022; Gutting, 2023).[5]

In the 1960s, the West German government's planning projects for nuclear power plants were carried out relatively quietly in order to avoid possible resistance from the population (Radkau, 1983; Meyer et al., 2024). By focusing on the negotiations regarding the siting of nuclear power plants along the German – Swiss border, this article provides an insight into a part of the history of water and nuclear energy that is not well known. West Germany's first commercial nuclear power plant, the Kahl plant on the River Main, went into operation in 1961. This was followed, in 1966, by the completion of the multi-purpose research reactor (MZFR-Mehrzweckforschungsreaktor) at the Karlsruhe Nuclear Research Centre near the Rhine River, and in 1967 the AVR experimental nuclear power plant at the Jülich nuclear research facility near the Rur River went into operation. On the Swiss side, construction of Beznau I on the River Aare had just begun in 1965 (Cioc, 2002; Mignon Kirchhof and Trischler, 2020; IAEA, 2023). As the first nuclear power plants were still under construction, states had neither experience to fall back on nor case law to which they could refer. Switzerland, in particular, orientated itself towards countries like the USA, the UK, and France and enquired about their experience with thermal pollution (Courvoisier, 1968; Hochstrasser, 1968).

According to J. Samuel Walker, the situation in the USA was similar to that in Europe, although the former had started expanding nuclear energy somewhat earlier. The US wanted to rely on it more heavily due to air pollution, however no legislative proposal could be pushed through in the 1966 to 1969 period. Although in 1967 hardly any energy companies were considering alternative cooling methods, more than half of the 85 nuclear power plants that were planned or being built in 1970 had cooling towers. Decisions by energy companies, along with the passing of the Water Quality Improvement Act and the National

[2] With regard to the Rhine catchment area in particular, works that should be mentioned include: Andrew S. Tompkins' *Better Active Than Radioactive!* (2016), which deals with the anti-nuclear movement in Germany and France in the 1970s; Stephen Milder's *Greening Democracy* (2017), which is about the West German environmental movement and the anti-nuclear movement from the late 1960s to the early 1980s; David Häni's *Kaiseraugst besetzt!* (2018), which covers the protest movement against the Kaiseraugst nuclear power plant in Switzerland; and Natalie Pohl's *Atomprotest am Oberrhein* (2019), in which the author analyses the Franco-German anti-nuclear movement from 1970 to 1985. Patrick Kupper's *Atomenergie und gespaltene Gesellschaft* (2003) constitutes an exception to the above as it examines the failure of the Swiss Kaiseraugst nuclear power plant from the corporate perspective.

[3] Worthy of mention here are Gabrielle Hecht's *The Radiance of France* (2009); Christian Forstner's *Kernphysik, Forschungsreaktoren und Atomenergie* (2019) on Austria; Tobias Wildi's *Der Traum vom eigenen Reaktor* (2003) on Switzerland; and both Joachim Radkau's *Aufstieg und Krise der deutschen Atomwirtschaft* (1983) and Joachim Radkau's and Lothar Hahn's *Aufstieg und Fall der deutschen Atomwirtschaft* (2013) on West Germany. The latter is an updated version of Radkau's work from 1983. There is also the monograph *Reaktorsicherheit für Leistungskernkraftwerke* by Paul Laufs (2018), which takes a generally favourable view of nuclear energy, while the author examines the development of nuclear power plant safety in West Germany from industrial, political and social perspectives, taking a distinctly historical approach.

[4] In *Störfall für die gute Nachbarschaft* (2012), Sandra Tauer looks at German and French energy policy in the 1970s, and in *Nuclearized River Basins*, Alicia Gutting and Per Högselius (2024) have made a first attempt to write a more comprehensive history of nuclear energy from a river basin perspective.

[5] Patrick Kupper's *Atomenergie und gespaltene Gesellschaft* (2003), as part of his work on the conflict around the nuclear power plant in Switzerland, covers the thermal pollution controversy around the Kaiseraugst nuclear power plant. In his article *Accepted to Cool*, Christian Götter (2024) analyses the social acceptance of cooling systems using the examples of the Oldbury-on-Severn nuclear power plant in the UK and the German nuclear power plants Biblis on the Rhine and Lingen on the Ems.

Environmental Policy Act by Congress, contributed to reducing thermal pollution in the US (Walker, 1989). Between the mid-1960s and the early 1970s, thermal pollution, particularly of rivers, was thus an important issue in both Europe and the USA. Switzerland and Baden-Württemberg also held their informative talks on the regulation of thermal pollution between 1967 and 1970. For this reason, the article is limited to that period.

My analysis examines the multiple layers of diplomatic negotiations in that period and the interplay between nuclear energy and transboundary river water management. It draws loosely on three theoretical frameworks – water diplomacy, transboundary water interaction, and multilevel governance. The management of transboundary rivers presents unique challenges because these rivers serve as fluid borders, blending into different national territories and responsibilities. This fluidity makes political management and the balancing of diverse interests more complex, while also heightening the importance of ecosystem preservation (Wolf, 1999; Hipel et al., 2015). These entanglements often stand for conflicts, but also for common interests (Steinberg, 2020). Cooperation, however, does not necessarily stand for success and appreciation of the fellow riparian states. Even when data is exchanged, the atmosphere can still be tense. The extent to which countries respect each other's interests should play a major role in the analysis of cooperation and conflict (Zeitoun and Mirumachi, 2008).

Water diplomacy, also known as hydro-diplomacy, is defined here as the practice of finding a common denominator among actors who share a water body. The primary aim is to avoid conflict and to use water resources peacefully. Water diplomacy is still a research desideratum, especially in the social sciences and humanities. In most cases, research dealing with water diplomacy conducts a detailed examination of negotiations between national governments, even though regional-level and non-governmental actors are equally involved (Grech-Madin et al., 2018). Water diplomacy, nevertheless, does not play an obviously prominent role in Europe as there is more frequent use of other concepts such as water governance or treaties. There, river basin organisations are often at the forefront when it comes to negotiating conflicts of interest between neighbouring countries (Schmeier and Zavadsky, 2021). Although in this case a river basin organisation existed, that is, the International Commission for the Protection of the Rhine (ICPR),[6] it was still in its early stages and was not involved in the initial negotiations between Switzerland and Baden-Württemberg. For this reason, the application of the concept of water diplomacy was more evident.

In a river basin, the power structures are always asymmetrical, though not inevitably according to geographical location along the river. Tensions between riparian states of transboundary rivers can arise when a state claims its absolute dominion over waters and thereby causes damage to other countries further downstream. This damage can be both ecological and economic. Upstream riparian countries tend to control the flow of water and thus can cause damage to downstream states. This concept is known as absolute sovereignty. Downstream states, on the other hand, like to apply the concept of absolute territorial integrity, which means that their water needs cannot be restricted by upstream states (Sindico, 2021). Marton and Szálkai (2017) and Vij et al. (2020) expand further on the tendency of upstream riparian states to exploit their position of power against downstream riparian countries. Power asymmetries are thus very often inherent in rivers and river basins, as hegemons are not always willing to respond to the needs of other riparian states. Indeed, hegemons sometimes do not even seek representation in river basin organisations or they boycott fruitful cooperation (Pohl et al., 2014). Cooperation between neighbouring countries thus does not necessarily mean the absence of conflict.

Diplomatic negotiations and cooperation between the riparian states of international rivers began increasingly to lead to agreements and treaties. Sehring et al. (2022) mention the 1964 Lake Chad Convention, the 1972 Senegal Agreement, the 1994 Danube River Protection Convention, and the 1995

[6] The ICPR was established on 11 July 1950 by Germany, France, Luxembourg, the Netherlands and Switzerland; its aim was to examine the pollution levels of the Rhine and to foster collaboration between riparian states around the river's protection (ICPR, 2019).

Mekong Agreement. Cooperation along the Rhine is often emphasised in the literature as another positive example (Allen and Mirumachi, 2010), however, until 1987, attempts at cooperation between the neighbouring Rhine countries of Switzerland, France, Germany and the Netherlands were only moderately successful. Verweij (1999) blames this lack of success on the hierarchical organisation of the countries, which also meant that although environmental problems were tackled at national levels, transnational cooperation to establish measures failed.

In both Germany and Switzerland, governance, administration and decision-making take place in a multilevel system that involves various actors and institutions at the federal and state levels. In order to do justice to the complexity of this system, the theory of multilevel governance is also included in the theoretical framework. In the case analysed here, multilevel governance is not only about the interaction of "supranational, national, regional, and local governments" (Marks, 1993); it is also about the involvement of non-governmental actors in political decision-making. The concept of multilevel governance originated in EU policy-making during the late 1980s, emerging from efforts to conceptualise the complexities of EU decision-making processes (Bache and Flinders, 2004). This article does not aim to fully capture the complexity of the various multilevel governance concepts; it seeks instead to highlight the intricate nature of decision-making and the challenges faced by the actors who engage in the diplomatic negotiations. The following factors are the core of the analysis: the role of law in the negotiations, the multilevel governance on both the Swiss and the German sides, and the role of research in decision-making.

The data presented here consists of archival materials from the Swiss Federal Archives in Bern and from the State Archives of the Baden-Württemberg Department Freiburg.[7] The documents from the Swiss Federal Archives that were consulted consist of dossiers dating from 1965 to 1972 from the Federal Office for Water Management, the Swiss Consular Service Centre in Bonn, the Directorate of Political Affairs in Bern, the Federal Office of Energy, and the Federal Office for the Environment.[8] The dossiers contain letters between the actors involved on the Swiss and German sides, articles from German and Swiss newspapers, expert reports, personal notes from various decisionmakers, minutes of meetings of the German and Swiss delegations, minutes of internal meetings of the Swiss delegation, and letters to ministries and political decisionmakers from the energy companies involved.

The dossier from the State Archives of Baden-Württemberg Department Freiburg comes from the Regional Council of Freiburg and its staff unit for cross-border cooperation from the 1968 to 1972 period.[9] This dossier also consists of articles from German and Swiss newspapers, correspondence between concerned ministries in Baden-Württemberg, letters from Badenwerk to the regional president in South Baden, printed matter from the Baden-Württemberg state parliament, press releases from Badenwerk, and correspondence between different Baden-Württemberg district councillors, the Baden-Württemberg Minister President and the Regional President in South Baden. In addition to the archival material, I have used printed matter from the documentation and information system for parliamentary materials of the German Bundestag, as well as articles from the online archive of the German news magazine *Der Spiegel*.

The documents from the Swiss Federal Archives were much more extensive than those from the German archives. For this reason, the focus of this article is more on the Swiss than the German perspective.

[7] All archival documents utilised in this research were originally written in German and have been translated by the author.

[8] The signatures of the dossiers used are as follows: Federal Office for Water Management E8170D-01#1986/152#735*, Consular Service Centre of Switzerland in Bonn E2200.161#1987/186#321*, Political Directorate in Bern E2001E#1980/83#265* and E2001E#1978/84#611*, Federal Office of Energy E8190B-01#1990/199#509* and Federal Office for Environmental Protection E3360A#1986/183#725*.

[9] Signature F 39/1 Nr. 302.

FINDINGS

The following sections take a closer look at the friendly talks and subsequent negotiations between the Swiss and Baden-Württemberg delegations from 1967 to 1970. The starting point was the Swiss government's plans to intensively nuclearise the Aare and the High Rhine. Table 1 gives an overview of the main events from 1965 to 1972. The year 1965 was chosen as it marks the beginning of the nuclearisation of the Aare, when Switzerland started to build the first commercial nuclear power plant Beznau I. 1972 was chosen as the end as this was the year when Germany decided to follow Switzerland's 1971 decision to make additional cooling methods compulsory due to the limited thermal capacity of the Rhine River. The actual talks took place from 1967 until 1970. 1965 and 1971/1972, however, mark important events.

Table 1. Timeline of the informative talks and negotiations.

Year	Date	Event
1965		Construction of Swiss NPP Beznau I begins
1966		Swiss Water Authority proposes the appointment of the interdisciplinary Baldinger Commission
		Swiss Federal Council appoints the Swiss delegation
1967	12-13 June	First informative talks between the Swiss and Baden-Württemberg delegations in Stuttgart
1968	August	Baldinger Report made available to cantonal governments and 10 large overland utilities
1969	March	Swiss electricity industry and the public gain access to the Baldinger Report
	March	Basel cantons criticise the federal government for excessive nuclear plans
	September	Baden-Württemberg Ministry of Interior publishes study on thermal capacity of flowing waters
	November	Thermal pollution becomes the main agenda item during the meeting of the International Commission for the Protection of the Rhine (ICPR)
	8 December	Swiss and Baden-Württemberg delegations resume talks in Zurich
	9 December	NPP Beznau I begins producing commercial electricity
	15 December	Federal Department of Transport and Energy issues site licenses for Leibstadt and Kaiseraugst
1970	29-30 January	Swiss and Baden-Württemberg delegations continue talks in Stuttgart, agreeing to allocate heat quantities based on a formula yet to be determined
	29-30 September	Germany and Switzerland begin official negotiations in Aarau
	14-15 December	Second negotiation meeting in Baden-Baden ends without agreement
1971	5 March	Switzerland bans once-through cooling for nuclear power plants
	November	ICPR recommends that member states equip future NPPs with additional cooling measures
1972		Germany implements a similar ban on once-through cooling

In order to emphasise the link between the historical study and the theoretical concept, the findings are divided into five subchapters. The approach is mostly chronological, but the analysis is divided into five categories including: the perceived need for nuclear energy; the role of law in negotiations; the multiple levels of governance involved in negotiations; the role played in decision-making by research, including its establishing of limits and its development of groundbreaking new rules; and the various forms that water diplomacy can take. The conclusion then brings together the most significant findings, highlighting their relevance and implications within the broader context of the article.

The perceived need for nuclear energy

After WWII, Switzerland developed an interest in the extensive expansion of nuclear energy because it wanted to position itself as an electricity-exporting nation. According to the Swiss actors from politics and the energy industry, larger nuclear power plants with 500 or 600 MW were only possible if they were European, that is, if they were built together with partner companies from Germany and France. This was due to the immense costs of building and maintaining large nuclear power plants (Badener Tagblatt, 1966; Elektro-Watt AG and Motor-Columbus AG, 1969). Due to the increased cooling water requirements, however, there was only a limited choice of possible nuclear power plant sites. Engineers from the Federal Institute of Technology Zurich (ETH) and Urs Hochstrasser, the Swiss Delegate for Nuclear Energy Issues, considered the lower reaches of the Rhine, Aare and Rhône as potential sites for 1000 MW power plants. Larger nuclear power plants on the Aare and Rhine could thus only be built in the immediate vicinity of the German and French borders (Hochstrasser, 1965; Klaentschi, 1965).

In Baden-Württemberg, on the right bank of the Rhine, much economic hope was placed in a nuclear future. Economic actors in the German High Rhine region saw as essential the construction of nuclear power plants in what they considered to be a neglected region. Due to its relatively remote location and its proximity to the border, the region's domestic economy was confronted with higher costs and tougher competition than elsewhere. Actors from the High Rhine economy mistakenly believed that the supply of electricity from nuclear power plants was cheaper and would therefore help to strengthen the region's economy (Mitteilungsblatt der Industrie- und Handelskammer Freiburg i. Br., 1969).

Switzerland's nuclear planners outperformed their German counterparts, facing significant pressure from the domestic nuclear energy industry. Competition over limited nuclear sites led companies like Motor-Columbus and Elektro-Watt to push the Swiss government for rapid approval of nuclear power plant locations. Both companies prioritised siting decisions as an approved site was a prerequisite to securing partnerships domestically and internationally. With electricity demand expected to rise in the 1970s and nuclear power plants requiring lengthy planning and construction, the urgency of this decision was strongly emphasised by the energy companies (Motor-Columbus AG, 1967). Germany and Switzerland were eager to collaborate on the construction and operation of nuclear power plants along the Rhine, however selecting a German partner energy company proved challenging. Switzerland preferred Rheinisch-Westfälische Elektrizitätswerke AG (RWE), while Baden-Württemberg advocated for Badenwerk, a wholly state-owned company. In both scenarios, financial risks would be shared by Swiss and German energy companies, however the allocation of profits differed. A partnership with Badenwerk would funnel profits to the state of Baden-Württemberg, whereas collaboration with RWE would direct profits to the Ruhr region.

Even if the countries had their favourites, the energy companies were still independent and had their own ideas regarding the expansion of their operations. The Nordostschweizerische Kraftwerke AG was solely responsible for the Swiss Beznau nuclear power plant on the Aare, only about 10 kilometres from that tributary's confluence with the Rhine. The Swiss corporation Elektro-Watt, together with the German corporation RWE, planned the Leibstadt nuclear power plant on the High Rhine, directly at the confluence of the Aare and High Rhine Rivers and thus only about 10 km from the Beznau power plant. In 1966,

Elektro-Watt's plans centred on eight nuclear power plants near Leibstadt and Au Island,[10] each with 600 MW, that is, a total of 4800 MW (Elektro-Watt AG, 1966). In addition, the Swiss corporation Motor-Columbus AG, together with Atel Olten and Electricité de France, planned the Kaiseraugst nuclear power plant. It was also on the High Rhine, about 40 km further downstream and just 15 km upstream of Basel (Aargauischer Wasserwirtschafts-Verband, 1966). One concern was that Leibstadt would have to be cooled with already-heated water due to its geographical proximity to Beznau, and that other downstream nuclear power plants would receive water that was accumulating more and more heat (Rheinischwestfälische Elektrizitätswerke, 1965b).

Due to the planning that had already begun with Swiss energy companies, RWE was more interested than Badenwerk in the construction of nuclear power plants along the High Rhine. Badenwerk's lack of interest became even more apparent in mid-1969 when it was revealed that the company, along with Energie-Versorgung Schwaben (EVS) – a Stuttgart-area utility partially owned by the state of Baden-Württemberg and various municipalities – was planning to build nuclear power plants further north in Baden-Württemberg. Together they had planned a larger nuclear power plant near Bruchsal on the Upper Rhine. The energy companies argued that economic considerations supported this decision and that nuclear power plants on the High Rhine would become attractive at a later date (Eberle, 1969; Stuttgarter Zeitung, 1969). Like the Swiss energy companies, the German energy companies Badenwerk and EVS argued in favour of building larger nuclear power plants to ensure economic viability, and these large investments could only be made in partnership with other energy companies (Badenwerk AG, 1969).

The role of law in the negotiations

In general, Switzerland could not decide independently how much water could be taken from the Rhine, but it was unclear which law applied. Water abstraction for cooling purposes was a question of customary international law,[11] which did not provide any concrete answers to the question of fair distribution. The riparian states thus had to take the interests of neighbouring countries into consideration. In concrete terms, this meant that, "Each state may only use a border water body to an extent that corresponds to the principles of good neighbourliness; the quantity and quality of water may not be arbitrarily changed excessively" (Hochstrasser, 1968).

An effective agreement existed between the Grand Duchy of Baden and Switzerland, and it was clear to all Swiss stakeholders that without the involvement of Germany it would not be possible to guarantee the safe cooling of future nuclear power plants. Furthermore, according to international law the German authorities had to be involved in decisions on water withdrawals (Eidgenössisches Amt für Wasserwirtschaft, 1966a). The Swiss actors referred back to the agreement of 10 May 1879 between Switzerland and the Grand Duchy of Baden. It stipulated a mutual consultation obligation with regard to all artificial installations in the water and on the shore between Neuhausen in Switzerland and below Basel. These installations also included facilities for water extraction and discharge. The purpose of this agreement was to prevent obstructions and damage to water traffic and the shore area of the other

[10] The nuclear power plant on Au Island was mostly of interest to RWE, which followed the public and governmental debate on thermal pollution with concern. The Au Island site was approximately two km downstream of Leibstadt on the High Rhine, near the German municipality of Albbruck. If the level of thermal pollution had turned out to be unacceptable, RWE would have been forced to choose the Schwörstadt site some 30 km further downstream. RWE considered the conditions on the High Rhine to be favourable, as the highest water level prevailed in the summer – coinciding with the highest thermal load – and the authorities had approved a temperature of 28°C (Rheinischwestfälische Elektrizitätswerke, 1965a).

[11] "Customary international law is based not on written laws but on consistent state practice along with states' belief that they are acting in accordance with a binding norm. Treaty-based international law and customary international law can exist in parallel and may be in conflict with one another; treaty-based international law will not necessarily override customary international law" (ECCHR, 2024).

state.[12] A further restriction was imposed by the Swiss Federal Act of 16 March 1955 on the Protection of Waters against Pollution (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1966). Additionally, authorisation for water extraction in Switzerland was a cantonal matter and the individual cantons along the Aare and the High Rhine had their own ideas about the use of the coveted river water resource (Eidgenössisches Amt für Wasserwirtschaft, 1966b). The representative of the Swiss Legal Service thus recommended the negotiation of a legal relationship analogous to water protection instead of water utilisation. This legal relationship could be established in agreement with existing treaties and agreements (Hochstrasser, 1968).

Baden-Württemberg proposed that the distribution of the heat load capacity of the High Rhine should be modelled on the distribution of electricity generated by jointly operated hydropower plants. The participation of energy companies was linked to this. As Badenwerk was Baden-Württemberg's favoured partner, the heat load of a nuclear power plant on the Swiss side could be credited to Baden-Württemberg if Badenwerk was involved in the operation of the nuclear power plant. In the case of RWE's participation, Baden-Württemberg did not want to recognise that the consumption of the cooling water capacity was credited to Baden-Württemberg (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1968).

This proposal was based on the power generated in nuclear power plants relative to the amount of cooling water withdrawn. Baden-Württemberg considered this allocation to be a reflection of the sovereign rights of both states. Under this arrangement, the electricity from a nuclear power plant operated by recognised partners would be considered to be the electricity production of the respective states within the partnership framework. Switzerland found the hydropower logic incomprehensible, however, arguing that the utilisation of water differed between hydropower and nuclear energy. While both types of plants rely on river water, in hydropower plants water is the medium for generating energy through natural gradients and volume, whereas in nuclear power plants water serves solely as a coolant and does not contribute to electricity generation (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1968). Accordingly, the Swiss delegation equated nuclear power plants and their water utilisation with other industries and their water utilisation, which was not comparable with hydropower plants.

Multilevel governance of the negotiations

As already indicated in the previous section on the role of law, various actors were involved in the friendly orientation talks. Some were directly involved and some others were influential without being part of the respective delegations. The Swiss delegation was appointed by the Federal Council and consisted of representatives from the Federal Office of Energy, the Federal Office for Water Protection, the Legal Department of the Federal Political Department, the Building and Roads Department of the Canton of Thurgau, the Water Management Office of the Canton of Thurgau, and the Water Protection Office of the Canton of Aargau (Eidgenössisches Amt für Wasserwirtschaft, 1966b). For the first informative talks on 12-13 June 1967 in Stuttgart, Baden-Württemberg sent representatives from the Ministry of the Interior, the Ministry of Transport and the Ministry of Economic Affairs, as well as from the South Baden Regional Council (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1968).

Germany and Switzerland generally tried to solve the problems around the distribution of cooling water and the competition for progress as amicably as possible. Neither country had any intention of

[12] The Ministry even went so far as to highlight the negotiations between Austria, Germany and Switzerland regarding water abstraction from Lake Constance and the fact that the three countries were in the process of concluding a treaty (Eidgenössisches Amt für Wasserwirtschaft, 1966a). There was also a treaty between Switzerland, Baden and Alsace-Lorraine concerning fishing that was dated 18 May 1887. Issues relating to fishing, navigation and bank protection were dealt with independent of each other on the basis of these treaties, an approach that the Swiss delegates preferred to maintain (Schweikert Delegierter für Atomfragen, 1966).

duping the other. This principle was maintained throughout the friendly orientation talks. Their concern for their own country's progress, however, was naturally in the foreground and cooperation did not always go smoothly. Both sides tried not to let conflicts escalate while also gaining the greatest advantage in terms of industrial development and use of water from the Aare and the Rhine. For this reason, there were also advantages to Switzerland negotiating with the Baden-Württemberg delegation rather than with the German government: the actors could refer to a history that was characterised primarily by amicable relations.

Switzerland wanted to reach local agreements to avoid the time that it would take for state negotiations to agree on a treaty. One argument that Switzerland used in its favour was that Baden-Württemberg supplied large parts of the state with drinking water from Lake Constance. This decision had been made without consulting Switzerland beforehand. In addition, the two German pumped-storage power plants, Schluchsee and Hotzenwald, were supplied with water from the Rhine. From the Swiss point of view, these facts were legitimate reasons for accelerating the authorisation of the Swiss nuclear power plants Kaiseraugst and Leibstadt (Motor-Columbus AG, 1967). All of these matters took place in Baden-Württemberg on the Swiss border, which had the advantage that a potential conflict could be resolved locally without it turning into a national conflict between the Federal Republic of Germany and Switzerland.

The threat of potential conflict, however, came not only from the other side of the border, it also came from within Switzerland where there were different interests and power imbalances. As already mentioned, water issues were a matter for the states and could not be decided at the national level. Potential conflict was already apparent in the selection of the individual members of the Swiss delegation. Aargau was represented because, with the exception of Mühleberg and Rüthi, all nuclear power plants were built or planned in that canton. Neither Basel-Stadt nor Basel-Landschaft were involved as downstream users even though these two cantons would have been the recipients of the water pollution.

The cantonal government of Basel-Stadt was concerned about the quality of drinking water, as there was talk of a total of three nuclear power plants on the Aare and Rhine, on the 70 km river stretch between Brugg and Basel (Beznau, Leibstadt and Kaiseraugst). Their concern centred both on impairment due to thermal pollution of the Rhine and on possible radioactive contamination from the Kaiseraugst nuclear power plant planned directly upstream of Basel. Basel argued that the national planning focus was too strongly on the energy sector (Eidgenössisches Amt für Wasserwirtschaft, 1966b; Regierungsrat Basel-Stadt, 1966; *National-Zeitung*, 1969):

> With all the understanding that the government council has for the long-term energy policy of the federal government and interested parties, it seems that it is very questionable that the thermal demand on a national body of water, such as the Rhine and its tributaries, is to be allocated to only one industry to the extent planned (*National-Zeitung*, 1969).

It was feared that there had not been sufficient consideration of the consumption of service water by other industries that were central to the economies of Basel and Schweizerhalle, such as the chemical industry. It was expected that the chemical industry would develop and that it would in future draw its service water not only from groundwater but also from the Rhine. The cantonal government of Basel-Landschaft went on to say that it was, "all the more astonishing that at the present time there is no need for this on this scale, since most of the energy generated by Swiss nuclear thermal power plants on the High Rhine is not to be used in the country at all" (*National-Zeitung*, 1969). In other words, they were highly critical of the vision of nuclear electricity exports.

The statement of the government council of the Canton of Basel-Landschaft also showed dissatisfaction with the responsible federal authorities. The project planning of five nuclear power plants on the Rhine and the Aare above Basel (Mühleberg, Gösgen, Beznau, Leibstadt and Kaiseraugst) would in future lead to considerable interference with the downstream cantons. It was also doubted that the German neighbour would agree to the "unilateral seizure of property", as intergovernmental talks had

been promised but not yet started. The cantonal government was against the expansion of nuclear power plants on the Aare and High Rhine as there was no practical experience with this still-new technology. The main fear was that the effects of nuclear power plants had not yet been sufficiently researched and that the well-being of an entire region was at stake *(National-Zeitung*, 1969).

Further warming of Rhine water by nuclear power plants would have meant a severe impairment of drinking water quality for the city of Basel. In 1969, the city drew 37,699,000 m^3 of water from the Rhine, which accounted for 80% of its total water supply. In addition, there were plans to increase the capacity of the Lange Erlen waterworks and to build a direct treatment plant for Rhine water. This plant was to pump 90,000 m^3 of water per day during the four summer months, which corresponded to 45% of the future daily average or 30% of the expected annual peak demand. The Canton of Basel-Stadt was therefore very critical of the nuclear power plants. Calculations showed that, especially in dry years, the temperature limit of 15°C would be exceeded, even without any artificial warming by nuclear power plants (Gewässerschutzamt Basel-Stadt, 1970).

The arguments put forward by Basel were not met with understanding in Aargau. For the representatives of the Canton of Aargau, it was clear that nuclear power plants were the best alternative, as otherwise oil-fired power plants would have to be built (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1969a).

The role of research in decision-making: Establishing limits and developing groundbreaking new rules

Even if the cantons had different views, the thermal capacity of the Aare and Rhine was decisive for the course of the talks between Baden-Württemberg and Switzerland. As Switzerland had initiated the talks with Baden-Württemberg, it was ahead of it with regard to the formation of the expert commission and the assessment of the thermal capacity of the Aare and the Rhine. As early as 1966, the water authority made the proposal to form a group of interdisciplinary experts consisting of authorities in mechanical engineering, limnology, fisheries biology, groundwater hydrology, and legal science. This commission was to determine the thermal capacity of the Aare and the Rhine as well as the legal implications (Eidgenössisches Amt für Gewässerschutz, 1966).

The Baldinger Commission, appointed in 1966 by the Swiss Federal Office of Home Affairs, was tasked with calculating the thermal load on the Aare and the High Rhine (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1969b). The Commission was named after Friedrich Baldinger, who headed the expert commission and was at that time Deputy Director of the Federal Office for Water Protection and was, from 1967 onwards, its Director (Fuchs, 2001). By the end of 1967, the Commission was ready to present preliminary results on the thermal pollution of the Aare and the High Rhine. These research results were essential for the further course of talks with Baden-Württemberg and for the approval of future nuclear power plant sites (Motor-Columbus AG, 1967).

The Baldinger Commission's report was entitled *Gewässerschutztechnische Gesichtspunkte im Zusammenhang mit der Kühlwasserentnahme und -rückgabe bei konventionell- und nuklearthermischen Kraftwerken* (Water Protection Aspects in Connection with the Withdrawal and Return of Cooling Water from Conventional and Nuclear Thermal Power Plants). It went far beyond the Water Protection Act enacted in Switzerland in 1955, as the latter did not take large hot water sources into account. The Baldinger Report stated that, after complete mixing, the returned cooling water should not heat the river by more than 3°C at any point. The maximum permissible temperature, also after complete mixing, was 25°C, which was 3°C below the previous maximum permissible temperature. The cooling water itself should not be warmer than 30°C at the discharge point into the river; in exceptional cases, the temperature was limited to 35°C. It was also established that water bodies only cooled very slowly and that the cumulative effects of various plants could therefore lead to problems (Hochstrasser, 1965; Innenministerium Baden-Württemberg, 1970a). In addition, fish were very sensitive to temperature, and

further heat effects could significantly affect their populations as well as disrupt the general drinking water supply (Courvoisier, 1968).

Table 2. Findings of the Baldinger Report.

Parameter	Requirement
Increase in river temperature	Returned cooling water should not heat the river by more than 3°C (after complete mixing)
Maximum river temperature	25°C (after complete mixing), 3°C below the previous permissible limit
Cooling water discharge temperature	Should not exceed 30°C at the discharge point into the river
Exceptional discharge temperature	Limited to 35°C in exceptional cases

Like Switzerland, Baden-Württemberg had commissioned a group of experts to carry out a *Studie über die thermische Belastbarkeit der fließenden Oberflächengewässer* (Study on the Thermal Capacity of Flowing Surface Waters). This was published by the Baden-Württemberg Ministry of the Interior in September 1969 and came to similar conclusions as did the Baldinger Report (Innenministerium Baden-Württemberg, 1969). On the High Rhine, the river temperature should not exceed 25°C after complete mixing across the cross-section. The total heating of the river was limited to 3°C, and in exceptional cases to 5°C (Innenministerium Baden-Württemberg, 1970a).

Even though the Canton of Aargau was a driving force in the nuclearisation of the Aare and the High Rhine, the canton's representatives did not want to neglect water protection. The cantonal government of Aargau reckoned that an accumulation of nuclear power plants could have a detrimental effect on fisheries. These negative effects would not only be limited to the Rhine Valley, but would affect the entire Rhine (Regierungsrat des Kantons Aargau, 1965). With regard to the existing agreement between Baden and Switzerland, the threat of thermal pollution from nuclear power plants could therefore not be neglected (Eidgenössisches Amt für Wasserwirtschaft, 1966a).

The publication of the Baldinger Report and the report from Baden-Württemberg coincided with the criticality[13] of Beznau I, marking the first time the Aare's cooling capacity transitioned from a conceptual idea to a practical application. Beznau II (350 MW) was under construction and was to become critical from 1972. Mühleberg (350 MW), on the River Aare above Lake Biel and thus above Beznau, was planned to go critical from 1971. The Swiss delegation also mentioned two other nuclear power plants on the Aare, Gösgen and Graben, neither of which had yet been planned. The energy companies Elektro-Watt and Motor-Columbus had applied for site licences for the two Swiss nuclear power plants on the High Rhine, Kaiseraugst (800 MW) and Leibstadt (600 MW). Kaiseraugst was to be operational by 1975/1976 and Leibstadt at the end of the 1970s at the earliest. Baden-Württemberg had yet to finalise concrete plans for the High Rhine; it aimed to install 800 MW of capacity in the region by the late 1970s, but no sites had been selected or applied for (Innenministerium Baden-Württemberg, 1970a).

There was nevertheless still no consensus on the fair distribution of cooling water resources, and during the second meeting of the delegations on 8 December 1969 in Zurich it emerged that there were different interpretations of 'fair allocation'. Baden-Württemberg assumed that fair meant a 50:50

[13] Criticality of a nuclear power plant refers to a stable chain reaction and the generation of electricity by the reactor. The first criticality date is the first date, "when each uranium atom that splits via fission releases enough neutrons to cause one additional atom to split" (Office of Nuclear Energy, 2024). It does not mean that a nuclear power plant is producing commercial electricity, but rather that a nuclear chain reaction is self-sustaining (United States Nuclear Regulatory Commission, 2021). Beznau I started its commercial operations on 9 December 1969, Beznau II on 4 March 1972, and Leibstadt on 15 December 1984 (IAEA, 2023). Kaiseraugst never left the planning stage due to public protest and for other reasons (Kupper, 2003).

distribution or a 55:45 split of the cooling water, calculated according to the respective bank length of Switzerland and Baden-Württemberg on the High Rhine. Switzerland, however, claimed all the water resources coming from the Aare. This meant that it asserted exclusive rights to all the water in the Aare while disregarding the rights and needs of Germany as a downstream riparian country. It furthermore meant that the construction of Beznau I and II with once-through cooling would already use up a large part of the cooling water capacity and the remaining capacity was reserved for Kaiseraugst on the High Rhine. The Aare, as an entirely Swiss river, supplies about half of the High Rhine's water at low water levels. In addition to the Aare water, Switzerland also counted the water of the High Rhine according to the length of the banks of the two neighbouring countries. Added together, this would mean a split of 80:20 in favour of Switzerland (Eidgenössisches Amt für Wasserwirtschaft, 1970a; Innenministerium Baden-Württemberg, 1970a).

The ratios of 55:45 and 80:20 were obviously significantly at odds and Switzerland argued for the privileges of the upstream riparian. At the same time, however, the Swiss delegation did not want to violate the principle of no significant harm in international water law (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1969a). [14] The German side had no understanding for the Swiss calculation, since heated water can persist for several hundred kilometres, depending on water resources, outside temperatures, and weather. Heated cooling water from the Aare would thus also be a German matter on the High Rhine and probably even on the Upper Rhine (Neue Zürcher Zeitung, 1970).

Table 3. Swiss proposal 80:20.

Region	Total heat load capacity (MW)	Distribution	MW allocation
Switzerland	1680	Beznau I & II	700
		Kaiseraugst	600
		Subtotal	1680
Baden-Württemberg	420		420
Total capacity	2100		2100

Table 4. Baden-Württemberg proposal 55:45[15]

Region	Total heat load capacity (MW)	Distribution	MW allocation
Switzerland	770	Kaiseraugst	600
		Remaining capacity	170
		Subtotal	770
Baden-Württemberg	630		630
Total capacity	2100		2100

[14] The 'no-harm' principle is one of the key principles of international water law. It became a significant part of the 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses and it is also reflected in transboundary water practice. The actual definition of the principle nevertheless remains fuzzy and depends heavily on the context of its application. How riparian countries define harm and equitable use is assessed on a case-by-case basis (Schmeier and Gupta, 2020; Tignino and Bréthaut, 2020).

[15] Both tables are simplified visualisations of calculations that were laid down in a document issued by the Swiss Federal Office for Water Management, entitled *Einige Gedanken zum Bau und Betrieb von Atomkraftwerken mit konventioneller Kühlung* (Some Thoughts on the Construction and Operation of Nuclear Power Plants with Conventional Cooling) (Eidgenössisches Amt für Wasserwirtschaft, 1970a).

The critical part of the Swiss proposal and their claim to 80% of the cooling water was that Beznau I and II and the Kaiseraugst power plants were planned without a cooling tower. In this scenario, neither Leibstadt nor any potential German nuclear power plant could be built with once-through cooling. Baden-Württemberg, and especially the southern part of Baden-Württemberg in the High Rhine area, felt threatened by this fast-paced industrial development of Switzerland. The Baden-Württemberg delegation therefore wanted to uphold their countering position to keep Switzerland from building nuclear power plants before an agreement was reached (dpa, 1970).

The most controversial point of the Baden-Württemberg proposal was that the Swiss Leibstadt on the High Rhine could not have been built with once-through cooling and would have needed cooling towers (Eidgenössisches Amt für Wasserwirtschaft, 1970a). Not being able to use once-through cooling would have been highly problematic from an energy industry perspective, one reason being that equipping the plant with cooling towers would have resulted in reduced energy efficiency and would thus have made the already expensive nuclear power plant even more expensive. Other issues also arose, including the socially contentious visual impact of cooling towers and concerns from shipping companies and winegrowers about a potential increase in fog in the surrounding area (Basler Nachrichten, 1971). Neither proposal factored Mühleberg – on the Aare upstream of Lake Biel – into their calculations as it remained uncertain how much Lake Biel would aid in cooling the heated cooling water (Eidgenössisches Amt für Wasserwirtschaft, 1970a).

Water diplomacy in action: From friendly talk between neighbours to a cooling water war?

The Swiss demand for 80% sparked outrage among the German delegation. This culminated in the Baden-Württemberg representatives issuing a press release without prior agreement from their Swiss counterparts. Switzerland thus learned from the press about the deterioration of the friendly talks and that there was now a threat of cancellation of the planned meeting for 29 and 30 January 1970 in Stuttgart (Lacher, 1970). Despite the fact that Baden-Württemberg and Badenwerk had no concrete plans to build nuclear power plants on the High Rhine, they were determined to retain the option of establishing a site for an 800 MW nuclear power plant on the High Rhine (Innenministerium Baden-Württemberg, 1970b). The Swiss demand for 80% of the cooling water posed a threat to these plans and the Baden-Württemberg Minister President Hans Filbinger felt compelled to raise the impending conflict from the state to the national level. In the opinion of the Baden-Württemberg representatives, the Swiss demands were not compatible with international water law and they therefore informed both Walter Scheel, the German Foreign Minister, and Hans Lacher, the Swiss Ambassador to Germany (Eidgenössisches Verkehrs- und Energiewirtschaftsdepartement, 1970; Lacher, 1970).

Switzerland felt caught off guard by the accusations from Baden-Württemberg as there had never been any official talk of an 80% cooling water claim by Switzerland. Baden-Württemberg had calculated this percentage themselves based on the negotiations, and this calculation was in turn presented as an exaggerated demand by the press and dubbed an imminent "cooling water war" (Schweizerische Delegation et al., 1970). Baden-Württemberg's Minister President Filbinger, in turn, said in a conversation with the Swiss Ambassador Lacher that the strong reaction from the press had come as a surprise to him too. Ultimately, both parties were still interested in a peaceful agreement and wanted to avoid an escalation of the conflict (Lacher, 1970).

It is not clear from the archival documents to what extent Switzerland was not aware of its 80% demands and to what extent the Baden-Württemberg press release was not calculated. In a subsequent conversation with Ambassador Lacher, Filbinger stated that he would not be able to refrain from informing the press about the progress of the talks in the future either. The fact was, however, that Switzerland was under enormous pressure as the talks had dragged on for two and a half years, and site licences for Kaiseraugst and Leibstadt finally had to be awarded (Innenministerium Baden-Württemberg, 1970b; Lacher, 1970).

A week after the 8 December 1969 talks, and following the uncoordinated press release, the Swiss Federal Department of Transport and Energy issued site licences for Leibstadt and Kaiseraugst. Elektro-Watt had initially applied for a license for Leibstadt on 1 July 1965 and Motor-Columbus for Kaiseraugst on 5 October 1966 (Eidgenössisches Amt für Energiewirtschaft, 1969a, 1969b; Schweizerische Botschaft Köln, 1970). The site licences, however, did not include any cooling water permits, which were still being negotiated with Baden-Württemberg (Eidgenössisches Amt für Wasserwirtschaft, 1970b).

The final friendly orientation talks nevertheless took place on 29 and 30 January 1970 in Stuttgart. During these talks, the delegations were able to agree that the heat quantities would be divided up appropriately between the two sides according to a formula yet to be determined (Tages-Anzeiger, 1970). In addition, neither of the countries were allowed to grant cooling water licences that exceeded their share of the heat load capacity. This meant that the planners of future nuclear power plants had to take into account that the use of cooling water by new plants could not exceed amounts used by existing plants and that, going forward, total cooling water use could not exceed the overall thermal capacity of the Rhine (Eidgenössisches Politisches Departement, 1970a). The Swiss and Baden-Württemberg delegations, however, were still unable to agree on a fair distribution (Schweizerische Delegation et al., 1970). The Federal Republic of Germany, in a note on 26 February 1970, reaffirmed its interest in entering into negotiations with Switzerland to clarify the cooling water issue (Politisches und Verkehrs- und Energiewirtschaftsdepartement, 1970).

When Germany and Switzerland finally began their negotiations on the High Rhine cooling water abstraction in Aarau on 29 and 30 September 1970, the talks were fairly unanimous until the German side refused to budge from its definition of the Rhine. All documents referred to the "cooling capacity of the Rhine River system upstream of Basel" instead of the "High Rhine" and Switzerland interpreted this definition as an unlawful encroachment on its sovereign territory. If Switzerland fully utilised the Aare, Germany would no longer have any access to cooling water between the mouth of the Aare and Basel. Switzerland could not accept this objection, as under international law it was not accountable to Germany for the pollution of the Aare. This disagreement resulted in a further postponement of the negotiations, although both delegations confirmed that they did not consider the negotiations to have failed (Schweizerische Delegation, 1970a).

This shows that the debate between Germany and Switzerland made little progress even during the official negotiations. The parties were unable to agree on the actual meaning of 'fair distribution'. As there were no clear guidelines in international law regarding the extent to which the water of international rivers should be shared, the negotiations stagnated. In principle, the negotiating parties agreed: they did not want to overburden the Rhine, but both wanted to be able to operate nuclear power plants as efficiently and economically as possible, which in this case supported river water cooling. The Aare contributed 50% of the High Rhine's water during low-flow periods, resulting in a significant thermal burden on the Rhine. In warmer months, heated water from the Aare did not sufficiently cool down, which had a profound downstream impact. This posed a significant challenge for the German negotiators, as Switzerland's plans primarily focused on constructing nuclear power plants along the Aare. This left little opportunity for once-through cooling for German nuclear power plants on the High Rhine; moreover, Swiss nuclear power plants could also potentially affect the thermal conditions of the Upper Rhine (Schweizerische Delegation and Baden-Württembergische Delegation, 1970).

The main challenge in terms of international law was the disagreement between Germany and Switzerland over the extent to which the rights and obligations of upper and lower riparian states along the Rhine were governed by international legal frameworks. The debate centred on a state's obligations to its downstream riparian neighbours with regard to the required condition of the main river or tributary water as it passes across their shared border. A second question addressed the level of maintenance of water quality standards that should be required to prevent harm and, in case damage did occur, how liability should be determined. In the context of thermal pollution, this issue translated into the need to ensure that heat input into the Rhine River system did not exceed a scientifically determined threshold.

Because of a dearth of concrete scientific data, however, this critical threshold remained undefined, and the lack of data was due to limited practical experience with the actual impacts of cooling water recirculation and the resulting thermal load.

Even though the issue was negotiated between only Germany and Switzerland, the decision or agreement would affect the entire Rhine catchment area. The equitable distribution of cooling water was not necessarily an issue under international law, however the potential impact on water quality caused by heat discharge was a significant concern. Taking both factors into account was a complex problem. Switzerland was not prepared to move away from its position that it should be able to use all Swiss tributaries autonomously within the tolerances of the Baldinger Report and that it also should have access to a half-share of the remaining capacities of the High Rhine (Schweizerische Delegation, 1970b). The two parties had not made any progress from their previous impasse. The Swiss delegation had gained the impression that the German delegation simply did not want to understand the Swiss point of view. The representatives of the Swiss Federal Office for Water Management were nevertheless confident that the German delegation would submit an interim offer that would come close to the Swiss demands (Eidgenössisches Amt für Wasserwirtschaft, 1970c).

The Swiss delegation also had to contend with internal contradictions. During the preparations for the second negotiation meeting with the German delegation on 14 and 15 December 1970 in Baden-Baden, representatives of the Swiss Federal Political Department, among others, realised that the previously used figures for the available megawatts (MW) on the Rhine were not compatible with the Swiss domestic heat load plan. The representatives of the Canton of Aargau were identified as the root of the problem. They had been particularly active in the negotiations thus far, as the Canton of Aargau stood to benefit the most, being the location of all existing and planned nuclear power plants except Mühleberg and Rüthi. The Federal Office for Water Protection calculated a total capacity of 2100 MW for the Rhine River system, covering both the Aare and the Rhine. Of this, 1050 MW was allocated to the Aare, to be fully utilised by nuclear power plants already in operation (Beznau I) or planned (Beznau II and Mühleberg). In the event of low water, the remaining 1050 MW would be available for the High Rhine. This capacity was to be divided approximately equally between Germany and Switzerland, resulting in about 500 MW each, not 850 MW as had been previously communicated (Eidgenössisches Politisches Departement, 1970b).

Table 5. Allocation of heat load capacity for the Aare and High Rhine Rivers: Breakdown by region and eventual distribution.

Aspect	Details
Total capacity of the Rhine system	2100 MW
Allocation to Aare	1050 MW (to be fully utilised by nuclear power plants planned or in operation: Mühleberg, Beznau I, and Beznau II)
Allocation to High Rhine	1050 MW (remains available in the event of low water)
Division for Germany and Switzerland	Approximately 500 MW each (not 850 MW as previously stated)
Previous communication issue	The impression was given that Germany and Switzerland could each claim 850 MW, leading to misinterpretation of the actual allocations

In previous discussions, the Swiss delegation had incorrectly implied that both countries could claim 850 MW each, leading to confusion over the allocations. If both countries had indeed claimed that amount, Switzerland would have been acting against its own heat load plan. This situation had arisen because Aargau was able to favour its own interests in the negotiations and no limits had been set for the canton by the Swiss Federal Government. The Water Protection Act took precedence here and it would have

been negligent to guarantee once-through cooling to future nuclear power plants. This problem was already evident at the Mühleberg nuclear power plant, which had exceeded the 3°C tolerance limit with its once-through cooling and was about to be warned by the Federal Office for Water Protection (Eidgenössisches Politisches Departement, 1970b).

The internal Swiss conflicts coincided with the Swiss delegation's growing realisation that the Aare and Rhine were not quite as resilient as Baden-Württemberg and Switzerland had thought at the beginning of their negotiations in 1967. Even though additional cooling systems for river water cooling had been repeatedly mentioned during internal discussions, the majority of the Swiss delegation had been of the opinion that Beznau I and II, Mühleberg, Leibstadt and Kaiseraugst could all be operated with once-through cooling. The Baldinger Report was made available in 1968, but by the conclusion of the negotiations in 1970, foreign studies had already validated the need for lower thresholds. It was established that the Baldinger Report's proposed 'exceptions' – allowing for a 5°C temperature increase or river temperatures reaching 30°C or even 35°C – were entirely unfeasible. The experts were also able to establish that the water quality downstream of Basel, in particular, did not permit the exceptional temperatures of 5°C and 30°C/35°C; instead, it appeared that the temperature should be reduced to a maximum of 25°C in summer and that the temperature of the receiving water could be increased by a maximum of 3°C (Eidgenössisches Department des Innern, 1970). These new findings indicated that cooling towers could become a reality much earlier, especially for the future Swiss nuclear power plants Kaiseraugst and Leibstadt, which were about to be awarded cooling water licences. This went so far that the Swiss Expert Commission for the development of heat load plans urged energy companies to take a possible reduction in output into account when planning future nuclear power plants as it would not be economically viable to carry out the necessary retrofitting of cooling towers (Eidgenössische Kommission Wärmelastpläne, 1970).

These new findings were particularly concerning for Switzerland. Since the German side had yet to develop concrete plans for its own nuclear power plants, discussions had thus far focused primarily on the partnership power plants at Leibstadt and Kaiseraugst. Switzerland sought to ensure that its future electricity needs would be adequately met. Swiss authorities deemed the construction of nuclear power plants to be indispensable and that only the Aare and High Rhine Rivers could provide sufficient water for cooling purposes. Securing control over these critical water resources thus became a top priority. The allocation of cooling water licenses for Kaiseraugst and Leibstadt was contingent upon negotiations with Germany; however, the extent of German energy companies' involvement in these Swiss nuclear power plants ultimately rested with the Swiss utilities Elektro-Watt and Motor-Columbus, which held decision-making authority in the matter (Eidgenössisches Amt für Wasserwirtschaft, 1970d).

The two companies initiated their intensive dialogue in 1969. It ultimately led to both Leibstadt and Kaiseraugst being constructed primarily as Swiss-operated plants. The German company RWE agreed to significantly reduce its initial 50% stake in Leibstadt, allowing the plant to remain predominantly Swiss while still benefitting from the political advantages of limited foreign ownership. Leibstadt was now set to be built with the involvement of four Swiss energy companies: Nordostschweizerische Kraftwerke AG (NOK), Bernische Kraftwerke AG (BKW), Energie Ouest Suisse (EOS), and Elektro-Watt. Foreign participation in Kaiseraugst was also substantially scaled back, the motivation behind this being, "to reserve the sites for nuclear power plants as far as possible for Swiss needs" (Eidgenössisches Amt für Wasserwirtschaft, 1970d). This also meant that future negotiations with Germany were conducted by the Federal Political Department, even though it was the Canton of Aargau that was actually responsible for granting the cooling water licences. The same situation had also arisen in Germany, as the state of Baden-Württemberg was actually in charge; however, as the Federal Republic of Germany treated the cooling water issue as a matter of international law, responsibility was transferred to the federal offices (Eidgenössisches Politisches Departement, 1970c).

The implementation of thermal limits significantly reduced transboundary electricity cooperation and prompted Switzerland to adopt a more protective stance towards its domestic electricity needs. This

marked a shift in the country's energy policy as it transitioned from its plan to become a major European electricity exporter to focusing primarily on generating electricity for its own consumption. The emphasis on safeguarding national resources and ensuring self-sufficiency became central to Switzerland's approach, reflecting the broader impact of environmental considerations on international energy collaboration.

Despite the more assertive stance adopted by the Swiss delegation, the German delegation remained unwilling to adjust its calculation of the heat load on the Aare. The strong discrepancy in the views of the respective delegations meant that the second negotiation meeting, held on 14 and 15 December 1970 in Baden-Baden, once again failed to achieve the hoped-for resolution (Schweizerische Delegation, 1970c). Representatives from the Canton of Aargau nevertheless maintained their optimism. Following this setback, Jörg Ursprung, the head of Aargau's Building Department, informed Emanuel Diez, chair of the Swiss delegation, that cooling towers for nuclear power plants along the Aare would be unnecessary if the thermal limits defined in the Baldinger Report were adhered to. Ursprung further emphasised that the Aargau government was eager to proceed with, and finalise, the licensing process as soon as possible (Baudepartement des Kantons Aargau, 1970).

Representatives of Aargau appeared unwilling to acknowledge that the planned nuclear expansion would far exceed the thermal limits of the Aare and High Rhine, making once-through cooling infeasible for most nuclear power plants. The existing or planned Beznau I, Beznau II and Mühleberg nuclear plants had already exceeded these limits, with thermal loads extending hundreds of kilometres downstream rendering further once-through-cooled nuclear plants untenable. The Baldinger Report had demonstrated that the original planning had been overly optimistic and had underestimated the impact on water systems.

In response to these findings, the Swiss delegation, led by the Federal Political Department under Emanuel Diez, began adopting a more cautious stance. Diez was urged by his consultant, Gottlieb Gut, to suspend further negotiations with Germany. Gut argued that no further talks were necessary as new measurements had indicated that any future nuclear power plants on the High Rhine would require an alternative cooling system from the outset. This conclusion was supported by evidence that industrial and wastewater discharges were already contributing significantly to the Rhine's thermal load. Experts projected that these discharges could soon account for up to 20% of the river's minimum heat load capacity during winter months with low water levels and low temperatures (Eidgenössisches Politisches Departement, 1970d).

Beznau I and II, each operating at 350 MW, also already exceeded the Aare's heat load capacity when in full operation. Uncertainty also surrounded the extent to which Lake Biel contributed to cooling Mühleberg's cooling water. With water protection becoming a top priority, Gut contended that the problem lay primarily within Switzerland and that further negotiations with Germany would not resolve the issue (Eidgenössisches Politisches Departement, 1970d; Neue Zürcher Zeitung, 1971).

At the same time, broader European discussions on thermal pollution were gaining momentum. Although the Swiss delegation was initially hesitant to involve the International Commission for the Protection of the Rhine (ICPR) in negotiations, in 1969 the German delegation pushed for its inclusion, highlighting the growing recognition of thermal pollution from nuclear power plants as a European-level issue (Meyer, 2025). Other ICPR member states (France, Luxembourg, the Netherlands and Switzerland) agreed, and the topic became the main agenda item at the November 1969 meeting (Eidgenössisches Amt für Wasserwirtschaft, 1969). While the ICPR had previously avoided addressing thermal pollution, bilateral talks between Switzerland and Baden-Württemberg underscored the central importance of water protection, prompting the ICPR to take up the issue (Eidgenössisches Amt für Wasserwirtschaft, 1969).

By November 1971, the ICPR recommended that member states require future thermal power plants to include additional cooling measures such as cooling towers (Badische Neueste Nachrichten, 1971;

IKSR, 1971). This recommendation aligned with the Swiss Federal Council's decision from 5 March 1971 (based on the Baldinger Report) to prohibit once-through cooling for nuclear plants not yet under construction. This decision, reached after consultations with cantons along the Aare and Rhine but without input from electricity companies, emphasised Switzerland's commitment to prioritising water protection (Genscher, 1972; Kupper, 2003). Although binding case law on thermal pollution was still lacking in member states, the ICPR's recommendations reflected a growing consensus. In 1972, the Federal Republic of Germany followed Switzerland's lead. German Interior Minister Hans-Dietrich Genscher urged other Rhine-bordering countries to place environmental protection above economic interests (Genscher, 1972).

CONCLUSION: UNDERSTANDING EARLY NUCLEAR WATER DIPLOMACY

In this article, I have demonstrated how combining historical research with interdisciplinary concepts such as water diplomacy, transnational water interaction, and multilevel governance can shed new light on the relationship between nuclear energy history and water management. This connection has so far been researched only to a limited extent. Thermal pollution in particular, which began attracting attention in the late 1960s, still represents a significant gap in the research.

The analysis focused on the historical negotiations between Switzerland and Baden-Württemberg that took place between 1967 and 1970 around the fair distribution of cooling water resources from the Aare and High Rhine Rivers. These discussions were analysed through the lens of water diplomacy, transnational water interaction, and multilevel governance. Particular attention was paid to the legal frameworks, the role of multilevel governance in shaping the negotiations, and the influence of scientific expertise in establishing temperature limits. By linking early nuclear energy history with these interdisciplinary concepts, this article has allowed for a deeper examination of the negotiations and their underlying dynamics.

The negotiations were initiated by Switzerland due to its plans to nuclearise particularly the High Rhine and the Aare, Switzerland's most water-rich Rhine tributary. Cooperation on the construction and operation of nuclear power plants along the shared border river seemed like an obvious choice for Switzerland and Baden-Württemberg. The economic burdens of nuclear power projects were immense and, in theory, both parties would be able to build on earlier successes in hydropower cooperation.

This initial understanding, however, soon revealed its limitations. The lack of experience with nuclear power plants introduced new challenges as did the environmental impact of nuclear power plants on the rivers whose water was required for cooling. Divergent views between the two sides quickly emerged as there were no legal regulations in place to govern the 'fair distribution' of cooling water. Switzerland and Baden-Württemberg had fundamentally different ideas of what fairness could look like. This was exacerbated by two critical factors. First, the Aare flowed entirely within Swiss territory and Switzerland rejected Baden-Württemberg's claims to cooling water from the river. Second, Switzerland was already moving forward with building nuclear power plants, while Baden-Württemberg had no concrete plans for development along the High Rhine. This ultimately led to increased nationalisation of the planned electricity capacity. While Switzerland's original vision was to become a European electricity exporter through the expansion of nuclear energy, the limited thermal capacity of the two rivers meant that the planned Swiss-German cooperation was scaled back and it was decided that the Leibstadt and Kaiseraugst nuclear power plants on the High Rhine would be built and operated primarily by Swiss energy companies.

Tensions also arose within Switzerland itself. These played out as an upstream-downstream conflict between Aargau, which stood to benefit from the planned nuclear power plants, and the Basel cantons downstream, which were concerned about the impact of heated cooling water on their drinking water supply and industrial activities. These internal disputes, combined with governance structures, created additional challenges in negotiating with Baden-Württemberg. In Switzerland, decisions about energy

policy were made at the federal level but water law was a cantonal matter. As a result, Aargau actively pursued its own interests and exerted pressure on various stakeholders both domestically and internationally.

The introduction of temperature limits for cooling water stands out as a significant achievement of these negotiations. Both Switzerland and Baden-Württemberg commissioned scientific studies to calculate the thermal resilience of the Aare and Rhine Rivers. At the time, the Rhine was already heavily polluted and additional thermal inputs would have worsened the situation. These studies also informed the relatively new International Commission for the Protection of the Rhine (ICPR), which, while lacking legislative powers, began addressing thermal pollution as an urgent issue and put forward recommendations on the matter.

While the negotiations were largely inconclusive, both the orientation talks and the official negotiations led to significant agreements. Both Switzerland and Baden-Württemberg acknowledged that protecting water resources had to be the top priority and that the thermal impact of expanding the energy sector must be mitigated. This marked a significant step forward, especially given that Switzerland's 1955 Water Protection Act did not yet account for thermal pollution. In the context of these developments, cooling towers became a prominent symbol of the reliance of nuclear power plants on river water for cooling.

These decisions aligned with the interests of both actors, however, and were only minimally about reaching a diplomatic compromise. The intensity with which Baden-Württemberg and Germany insisted on incorporating the Aare's water into the calculations, and the equally strong opposition from the Swiss delegation, constituted an impasse. Ultimately, the Swiss actors recognised that the issue was predominantly internal to Switzerland and that continuing negotiations with Germany would not resolve the underlying challenges.

These early negotiations remain relevant today, particularly when viewed in light of historical efforts to establish temperature limits for cooling water and to ban once-through cooling due to its devastating ecological impact on river ecosystems like those of the Aare and the Rhine. Despite these early measures, the Rhine River system remains significantly thermally polluted, largely due to nuclear power plants (Raptis and Pfister, 2016; Raptis et al., 2016). In recent years, the effects of climate change – including seasonal low water levels and extreme heat waves – have exacerbated these challenges. Nuclear power plants have faced temporary shutdowns to prevent further harm to water bodies, while energy companies such as Électricité de France (EDF) have prioritised maintaining electricity supply over water protection (Gutting et al., Forthcoming).

In hindsight, the vision of once-through-cooled nuclear power plants on the Aare and High Rhine Rivers would have been unsustainable from a water protection perspective on the basis of calculations from the 1960s and 1970s and by today's environmental standards. This raises pressing questions about whether the temperature limits set during that time remain justifiable and whether the ongoing operation of freshwater cooled nuclear power plants on rivers can be considered environmentally sustainable.

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