Accepted to Cool: Conflicts about Cooling Technologies for Riverside Nuclear Power Plants

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Christian Götter *

Abstract: *»Zur Kühlung zugelassen: Konflikte um Kühltechnologien für Kernkraftwerke in Flussnähe«*. This article analyses the acceptance or rejection of riverside nuclear power plants' cooling systems. Based upon the case studies of Oldbury-on-Severn in Gloucestershire in the United Kingdom and the German plants Biblis in Hesse and Lingen in Lower Saxony, it argues for two intertwined hypotheses: First, that artificial cooling facilities played an important part in galvanising resistance to planned nuclear power plants. The larger their visible impact on their surroundings was, the greater the resistance they aroused, up to the point of becoming primary targets of nuclear power's opponents. Second, that even the largest, most far-reaching, and most visible artefacts could be made acceptable to the local public if, in addition to the features technically necessary for the intended cooling effect, the cooling systems were also equipped with features that were regarded as positive for the surrounding environment and social life.

Keywords: Nuclear power, environmental history, history of technology, cultural history, atomic energy, Britain, Germany, water.

1. Introduction

In 1967, two northern German electricity suppliers, the Nordwestdeutsche Kraftwerke AG and the Hamburgische Electricitäts-Werke AG, applied for a licence to build one of Germany's first commercial nuclear power plants in Stade, at the River Elbe, just north of Hamburg. There was little resistance, and construction works began in the same year. Five years later, the Stade nuclear power plant commenced operations (Götter 2018, 203, 207). Looking at a picture of the power plant, it is rather striking that one building often visible at riverside nuclear power plants is amiss: There is no cooling tower. Indeed, in Germany, such cooling towers, employed to reduce the

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temperature of a power plant's cooling water before returning it to the river it was taken from, were unusual for early riverside reactors. There was none at Kahl, Gundremmingen A, Obrigheim, or Lingen. And even though they became rather common from the early 1970s onwards, they remained absent from those reactors that were sited at the River Elbe around Hamburg. When Stade's atomic power plant launched operations in 1972, journalist Dieter F. Hertel explained in an article in the local newspaper, *the Stader Tageblatt*, that, while a nuclear power plant effectively converted only about one third of the thermal energy it produced into electricity, the temperature of the River Elbe was increased by a maximum of 0.1 degrees Celsius (*Stader Tageblatt* [ST] 1972a).[1] The Elbe had, in other words, been incorporated into the power plant that had been erected at its banks or, more to the point, incorporated into it in turn. River and power plant had been blended, forming an envirotechnical system with overlapping and no longer clearly separable technical and biological components (Pritchard 2011, 11-24; 2012, 219). As part of its cooling system, the river now enabled the nuclear power plant's operations by carrying away excess heat, in turn becoming warmer, richer in oxygen and slightly more radioactive itself (ST 1972b, 1977; Ministry of Social Affairs, Lower Saxony 1972). It had been, one could say, turned into an Atomic River,[2] a part of a "nuclear landscape," not in the sense of a more or less clearly circumscribed park, as John Wills used the term (Wills 2001), but fluid and borderless (cf. Pitkanen and Farish 2018, 863, 874). After all, while heat and radioactivity were diluted in the Elbe's waters, and more so once the river entered the sea, they did not simply vanish. Radioactive particles, in particular, remained detectable over long periods of time, at far-away places. To most historical actors at the time, however, power plant and river, technical system and environment, remained clearly separable from one another (cf. Hughes 1983, 5-17). The lower Elbe, to them, seemed not to acquire a nuclear status, seemed to avoid what Gabrielle Hecht called "nuclearity" (Hecht 2012, 3-4). To the people who had been reconfiguring Germany's waterways as seemed fit for about two hundred years (Blackbourn 2008), the stream was deemed large enough, in accordance with the rules and regulations in place, to cope with the effluents of the technological system at its banks without suffering negative consequences regarding its function as a biological one, without any further adaptations necessary.

This, however, was not always so. Many prospective operators of riverside nuclear reactors were faced with the challenge of having to technically improve "their" rivers' cooling capacities, either because they were

[1] As newspaper articles were not always provided with a byline, for consistency, they are quoted by newspaper name and date in the text and sorted accordingly in the reference list.

[2] "Atomic Rivers" was the title of a panel at the European Society for Environmental History Conference 2023 in Bern, organised by Alicia Gutting. I am thankful to her and Per Högselius for the chance to discuss an earlier version of this paper.

overburdened by numerous industrial plants, especially from the 1970s onwards, or because they did not provide enough cooling water from the start, or at least not always. The resulting measures tended to be publicly contested. Large-scale cooling towers, visibly incorporating the air above and beyond the power plant into the envirotechnical system, could even become, as the well-researched example of Wyhl in southern Germany demonstrates, the focal point for anti-nuclear protests – which, in this specific case, are held to have been the jumping-off point for the German anti-nuclear movement overall (Cf. Rucht 1980, 80-6; Rüdig 1990, 129-35, 148-9, 233-5).

In this paper, I am focusing not on the nuclear reactors, but on the cooling systems themselves, on the way they were perceived and interpreted in local and regional public discourse, and on their acceptance or rejection by the neighbouring population (Landwehr 2008). To this end, I discuss three examples from Germany and the United Kingdom where different technical solutions were sought to overcome various hurdles presented by rivers that were to be turned into Atomic Rivers used to cool nuclear reactors. In doing so, I submit the following two intertwined hypotheses: First, I argue that artificial cooling facilities always played an important part in galvanising resistance to planned nuclear power plants and that the larger their visible impact on their surroundings, the greater the resistance they aroused, up to the point of becoming primary targets of the nuclear power plants' opponents. Second, I demonstrate that even the largest, most far-reaching, and most visible artefacts could be made acceptable to the local public if, in addition to the features technically necessary for the intended cooling effect, they were also equipped with ones that were regarded as positive contributions to the surrounding environment and social life.

The three examples focused on here are the British power plant near Oldbury-on-Severn and the German ones at Biblis and Lingen. All three are part of a sample of six sites of atomic reactors I researched as part of a larger history of the local reception of nuclear power plants in Britain and Germany, which was conducted at the TU Braunschweig and at the Deutsches Museum in Munich. It was funded by the German Federal Ministry of Education and Research.[3] The project analysed local public debates about nuclear power in communities adjacent to nuclear power plants. The analysis was based upon the documents produced by local and regional parliamentary bodies, local and regional administrations, during licensing procedures, and, most of all, upon local and regional newspapers as important mirrors of, arenas for, and participants in the debates in question. In fact, the newspapers analysed tended to provide more details and information than even the protocols of most local parliamentary bodies, besides the fact that they also included

3 The research project "Splitting Societies – Local Debates About Nuclear Energy in Britain and Germany" was funded by the German Federal Ministry of Education and Research as part of the programme "Kleine Fächer – Große Potentiale."

various reports, interviews, and letters to the editor – with the latter providing important insights in more critical elements in the local discourse. The relevant documents referred to here were retrieved from the Gloucestershire Archives in Gloucester and the National Archives in London in the case of Oldbury, Biblis's municipal archive in the case of Biblis, and the Lingen City Archive in Lingen's case (regarding the introductory example of Stade, files from Stade City Archive and the Stade section of the State Archives of Lower Saxony were used). The present analysis demonstrates that the source documents upon which the project was based can be fruitfully employed for further questions, beyond the ones originally in focus. In this case, they allow for insight into the public debates of three communities in Britain and Germany, where nearby rivers were transformed into Atomic Rivers by integrating them into a nuclear power plant's cooling system, thereby creating envirotechnical systems. These technological interventions into the fluvial landscapes were contested to very different degrees, depending on the specifics of the interventions undertaken.

In Oldbury-on-Severn, an artificial reservoir inside the tidal river was to guarantee the availability of cooling water at low tide. Critics, however, whose experience-based expectations ultimately proved more reliable than the model-based calculations of industry experts, gained scant attention for their protests against the construction within the river. In the case of Biblis, widely visible cooling towers became a major point of attack for opponents of the nuclear power plants as their size increased with the number of reactors planned. Finally, in Lingen (Ems), an artificial lake was to ensure the cooling capacity of the Ems in dry periods. Opponents of the power plant, who focused on the lake and its dams, fought hard to stop its construction, but failed when it became acceptable to the wider population, not least because of the integration of biotopes and recreational facilities. To proceed chronologically, I begin with Oldbury.

2. Oldbury: Accepting a (Partially) Invisible Cooling System

The nuclear power plant that was to be built near Oldbury-on-Severn in Gloucestershire in the late 1950s was not situated at the sea, like many other British atomic reactors, but on the banks of a river. The river in question was the Severn, Britain's longest river, and a tidal one, with a differential in tidal height of about 13 metres around Oldbury (*Thornbury Gazette* [TG] 1959d). Therefore, the cooling water for the reactor, which was considered as a "principal technical requirement for the current type of nuclear station" by the supply industry (Buchanan and Linton 1960, 7), was not regularly available in sufficient quantities. Twice every day, at low tide, scarcity loomed, if water was not to be acquired by way of long and expensive artificial tunnels and pumps from farther out in the river (TG 1959d). To solve this problem, the Central Electricity Generating Board (CEGB), England's and Wales's state-owned utility, planned to construct a tidal reservoir on a rock shelf in the river, just in front of the site chosen for the power plant's construction.

Early in 1958, the CEGB's plan to erect, in addition to an already existing station near Berkeley, another nuclear power plant in the area of the Severn Estuary became public knowledge. Initially, several places were under consideration, with Oldbury among them. The area's county council favoured a site on the other side of the river, near Lydney, not least because of the jobs involved, while the CEGB preferred Oldbury, where lower infrastructure costs were projected (TG 1958, 1959a). In addition, cooling water, which "had to be free from sand and grit in suspension" was deemed easily accessible here (Buchanan and Linton 1960, 7, 15-8). To cool the turbines of the power plant, with its initial target of one gigawatt capacity, about 360,000 cubic metres per hour were considered necessary (TG 1959b). Later, the planned electrical output was reduced to about 550 megawatts, necessitating roughly 136,000 cubic metres per hour. Nevertheless, the reservoir was to be designed so as to be able to provide for a later expansion to or beyond the initially aimed-for capacity (TG 1960). To secure the amount of water needed during low tide, a reservoir containing about 2.4 million cubic metres was to be constructed inside the river itself, blending it with the power plant into an envirotechnical system (TG 1958, 1959a, 1964a). When the CEGB finally applied for the licence to construct its power plant in 1959, this "artificial tidal reservoir" was to be built on top of an outcrop of bedrock on the southeastern bank of the river, which was also to support the power station itself on the land side (TG 1959a, 1959b). The reservoir was to cover an area of about 1.4 square kilometres, enclosed by walls reaching, on average, the height of the highest natural rocks in the river, about half the normal tide level. Within the walls, excavations were to provide extra capacity for storing water during low tides. The CEGB considered the consequences of the construction – and of returning used water into the river at about 15° F above the temperature it had at the time of extraction – negligible (TG 1959d; Buchanan and Linton 1960, 17-9). The Board "appreciated that the Severn would change, as it had done before and would continue to do so, but [...] the reservoir itself would have no effect on the changes" (Buchanan and Linton 1960, 22).

Soon, these plans for a nuclear power plant near Oldbury were viewed critically, for numerous reasons. These included the dangers posed by nuclear power plants to their surrounding areas, especially when many were agglomerated in a small region, and most especially in times of war. Moreover, the industrialisation of a rural area and the loss of valuable farmland were highlighted, as were the consequences of the reservoir itself – the, in other words, (continued) transformation of the Severn into an Atomic River (TG 1959b). Indeed, the reservoir dominated most of the discussions during the public inquiry, where arguments for and against the CEGB's plans were exchanged under the eyes of Inspectors A. H. F. Linton from the Ministry of Power and C. D. Buchanan from the Ministry of Housing and Local Government, who then reported to the Minister of Power. The inquiry started on 12 April 1960 and went on for four days, albeit with a rather long break. It ended on 3 May, with a visit to a model of the Severn that was used by the CEGB's experts to simulate the reservoir's consequences for the river. In total, about 42 of the 75 pages of the inquiry's report were taken up by questions regarding the reservoir, especially by its critics' statements (Buchanan and Linton 1960).

These critics were, on the one hand, the fishermen directly affected by the river's transformation, in particular Tom J. Cornock and Sidney Terrett, as well as the experienced fisherman Colin Cook, but also The Severn Estuary (Nets and Fixed Engines) Fishermen's Association (Buchanan and Linton 1960). They were supported, not least, by Oldbury Parish Council (TG 1959c) and Sir Algar Howard, one of Gloucestershire's Deputy Lieutenants,[4] who had fished with one of the families directly affected for half a century, and was aware of the 500-year-old fishing tradition threatened by the CEGB's plans (TG 1959d).

The critics highlighted the consequences the reservoir would have for themselves and could have, indirectly, for other fishermen. They also pointed out its consequences for the river itself. Third, they identified errors in the reservoir's conception. Finally, they raised a methodological point when they criticised the fact that the CEGB relied solely on scientific and technical experts, while ignoring the experience and expertise of people who worked and lived with the river, on the river, and even in the river day in, day out (Buchanan and Linton 1960, 52-4; cf. Wynne 1998, 19-46).

The fact that the reservoir would affect the five fishermen whose fishing grounds lay within its limits was, indeed, noncontroversial (Buchanan and Linton 1960, 26, 30): Their fishing rights, which went back for centuries in some cases and had been codified during the mid-19th century, would be extinguished (Buchanan and Linton 1960, 31-2). Compensation was practicable only in monetary terms, because the affected fishermen could not relocate their fisheries: Fish were caught here with special baskets, installed in channels within the rock formation, to which fish were guided during the falling tide by way of fixed fences (Buchanan and Linton 1960, 31). The second fishing style practised locally, which employed what are known as "lave nets," would also become impossible in the immediate downstream area of the reservoir, as it was possible only just before low tide or, in other words, during the hours in which the water was now to be restrained inside its walls – and

[4] He was one of the assistants of the area's Lord Lieutenant, the regional representative of the crown.

with it, the fish (Buchanan and Linton 1960, 28, 32). And while those directly affected, and even other fishermen further downstream potentially affected, were to be compensated for their loss of income (Buchanan and Linton 1960, 51, 67; cf. TG 1960), there clearly was no way to compensate the loss of tradition, the loss of a centuries-old way of life (Buchanan and Linton 1960, 31).

Those who worked and lived with the Severn on a daily basis also emphasised that the river itself could be affected by the reservoir, far beyond its walls. They pointed out potentially changing currents and sandbanks, and perhaps even a displacement of the riverbed itself. Access to a nearby harbour could be blocked by silting. The critics based their prognoses on observations of the consequences of a wreck that had come to rest in the river years ago, which had affected wider parts of the Severn (Buchanan and Linton 1960, 34-7, 47). The CEGB, however, dismissed these predictions based upon the analyses of their own experts (Buchanan and Linton 1960, 67-72) and comments from others like the Gloucester Pilotage Authority (Buchanan and Linton 1960, 28-30).

Regarding their third argument, the local experts expected the reservoir to silt up inside so quickly that it would be near impossible, or at least very expensive, to dredge it (Buchanan and Linton 1960, 36, 39, 43, 45-6, 49). They expected, in other words, that the reservoir would not be able to function in its planned role as the power plant's cooling system, which would reduce its construction to absurdity. The CEGB, however, was not convinced by this argument either (Buchanan and Linton 1960, 67-72). It insisted on relying on its own experts and on their statements that the reservoir would have negligible consequences for the river – which, besides, was no longer considered a natural waterway, as it had been dammed in (Buchanan and Linton 1960, 2).

Against this background, for all the sympathy they expressed regarding the fishermen directly affected and the rural English landscape, the inspectors in their report backed the CEGB's position (Buchanan and Linton 1960, 75-6). The minister also concurred, and the power plant and the reservoir were built near Oldbury (TG 1962b, 1964a). The latter was finished by 1964 (TG 1964b), while the former went online seven years after construction works had commenced, in 1969 (TG 1962b, 1969).

Consequentially, the fishermen directly affected lost their fisheries and even others later saw a decline in business (TG 1962a; cf. TG 1970). Of course, none of them had, as Oldbury-on-Severn Parish Council had conceded early on, lived from fishing alone (Oldbury-on-Severn Parish Council 1959, 371). And, as Sir Algar had pointed out, while one could rightly lament the loss of fishing tradition in the area, one also had to accept the power plant as long as one wanted to be supplied with electricity (TG 1959d), which had only arrived in the municipality during the 1950s. So, when the construction work was finished, Oldbury's Parish Council Chairman, Douglas J. Winstone, looked ahead and saw the nuclear power plant as a "great civil engineering feat[s] of this decade," which had been well integrated into its surroundings – although he hoped that no further industrialisation would follow (TG 1969).

The local experts, however, were proved right regarding another of the prognoses: Already in 1964, the reservoir had begun to silt up, contrary to the CEGB's experts' calculations (TG 1973), and by 1972, dredging had become necessary to combat a sandbank that had started to form inside it (TG 1972). From 1973, a boat was stationed inside the reservoir to keep the sand that was dissolved within the water from settling (TG 1973). Nonetheless, dredging remained necessary during the following years (*Northavon Gazette* [NG] 1975, 1979). One could even argue that the machines clearing the reservoir became another component of the envirotechnical system developed near Oldbury-on-Severn.

In any case, although local people rejected the idea of another power station in Oldbury and discussed the technology quite critically when a leukaemia cluster was observed nearby in the 1980s (*New Scientist* 1988, 55; NG 1984a, 1984b, 1984c, 1984d, 1984e), nuclear power still enjoyed a positive reputation overall in the Oldbury area. In the long run, even the reservoir was accepted. After all, it was not visible half the time – and when it is visible, it has come to be considered photogenic – at least, one can buy pictures of it, taken as part of a photographer's collection of impressions of the British coast (Lake, n.d.).

In sum, then, the example of Oldbury-on-Severn and the reservoir constructed there show that the transformation of the Severn into an Atomic River was accepted in the end, even though the intervention in form of a reservoir nearly taking up one and a half square kilometres had been rather extensive; even though it had endangered local fishing traditions and extinguished, in some cases, ways of life many centuries old; and even though it turned out to be harder to uphold than had been calculated by scientific-technical experts. It was acceptable because, all told, these consequences were limited. After all, while the reservoir did not improve the local environment or the local community's social life at all, it was visible only temporarily – and, therefore, seems to have not been well suited to raise ongoing protest.

3. Biblis: Rejecting a Cooling System Out in the Open

In Biblis, on the Rhine in southern Hesse, the situation was somewhat different. While a first nuclear power plant started being constructed by the Rheinisch-Westfälisches Elektrizitätswerk AG (RWE) in 1970 without conspicuous alterations being made to employ the river as part of its cooling system (cf. *Darmstädter Echo* [DE] 1970; *Mannheimer Morgen* [MM] 1970b), it became clear that the Rhine's capacities for cooling were limited, especially in view of the numerous industrial plants built or planned on its banks, among them several nuclear power stations envisioned in the vicinity of nearby

Mannheim alone. This situation was exacerbated by the fact that the river was to be used to cool technological facilities beyond Germany, in France and Switzerland – and too high a temperature of the river's water was considered extremely problematic for its feasibility as a biological habitat, especially since the oxygen content of the water would change with the temperature. Consequently, at the turn of the 1970s, governments in and beyond Germany considered limiting the maximum heat load of the Rhine and prescribing cooling towers for new industrial plants to dissipate temperature into the air instead of into the water (cf. Cioc 2002, 136-9). As indicated, however, the first Biblis nuclear power plant was already under construction at this point in time (MM 1970a) – without cooling towers, although these had been called for by the "Schutzgemeinschaft Deutscher Wald" (German Forest Protection Association), which kept up its demand during the construction phase (DE 1970). Initially, RWE had been able to avoid any obligation to build cooling towers by agreeing "to reduce production if necessary in case of danger" (MM 1970b). The situation began to change, however, when the "Arbeitsgruppe Wärmebelastung der Gewässer" (working group for the thermal pollution of waters) which was established by the German Federal States in 1968, demanded in 1971 that the Rhine was not to be heated to more than three degrees Celsius beyond the 25° common during summer months and decreed that any water that was to be introduced into the river must not be above 35° C (*Hessischer Kommunal-Anzeiger* [HKA] 1971a). From now on, that much was clear, new industrial plants in Hesse would not be allowed to heat the River Rhine any further and would therefore have to be furnished with cooling towers (*Wormser Zeitung* [WZ] 1971).

In view of this situation, RWE, despite a lack of enthusiasm for cooling towers because they reduced a power plant's output by about five per cent (HKA 1971a), was nonetheless pondering their construction when it applied for the licence to build a second nuclear power plant in Biblis (*Südhessische Post* [SP] 1971). Hesse's Minister for the Environment Dr Werner Best, however, now demanded cooling towers not only for the newly planned reactor, but also for the one that was already under construction. With a view to the coordination with France and Switzerland, these were now considered necessary, especially during the autumn months, when higher electricity demands coincided with low water levels in the Rhine (HKA 1971b).

The critics who had been worried about the Rhine's temperature may well have been appeased by the cooling towers now to be constructed beside the atomic reactors. Others, however, seemed to be mobilised by just this prospect, and they turned out to be way more vociferous. Soon, the worry that cooling towers could lead to fog, already verbalised at other places, was adopted in the debates around Biblis. In January 1972, it was voiced in Mainz, about 30 kilometres away (*Mainzer Anzeiger* 1972). In Darmstadt, about 20 kilometres from Biblis, it was first and foremost the cooling towers' height that spawned critique – in other words, their spoiling the landscape. Some feared that the towers could rise up to 180 metres high. A 160-metre version was publicly put in relation to the 33 metres of a local landmark, a commemorative column dedicated to the Hessian Grand Duke Ludwig I – which was dwarfed even by the four 80-metre towers that were ultimately constructed (DE 1972a, 1973b; SP 1972; cf. WZ 1973e, 1973g). In Lorsch, meanwhile, 10 kilometres from Biblis, peoples' worries resembled those voiced in Mainz, focusing on the potential effects of the cooling towers on the local climate (DE 1972b). And when environmentally-minded people met in Hamm am Rhein in 1973, less than two kilometres from the power plant, they, too, focused on the cooling towers' potential environmental effects – among other aspects of the reactors (WZ 1973a). Specifically, Dr Hans von Rudloff, a meteorologist from Freiburg, warned that they could lead to fog and more rain and thunderstorms during the summer months and to more black ice during the winter. In addition, clouds and severe weather could become more common (WZ 1973b). These prospects clearly had regional viticulturists – wine-growing areas were located, for example, about seven kilometres from Biblis to the west of the Rhine (WZ 1973f) – worried that "[t]he grapes' quality could suffer" and that, in this way, the power plant could lead to large financial losses for them. Losses of up to 100 million Marks per year were aired (DE 1973a).

Of course, people in the Biblis region were not only concerned about the expansion of the local envirotechnical system; however, these worries were very much present among those that motivated people to sign petitions, to become active in citizens' initiatives, or to turn to politicians like Minister Best (DE 1973a; WZ 1973c). But while this kind of unease was not restricted to the Biblis region – it could be observed at other locations along the Rhine during the early 1970s, including Wyhl, as mentioned above – with cooling towers and their potential consequences for the local climate and for viticulture, especially, clearly of concern to local people, state governments remained unmoved. Even while an expert assessment of the cooling towers' effect on the local climate in Biblis remained outstanding, the Ministry of Economics and RWE were convinced that they would impact neither the climate nor the vine. RWE point-blank refused to accept any environmentally motivated criticism, as it claimed to have, "long before environmental protection became a fashion, even an obsession, for the wider public," itself aimed to protect the environment (SP 1973a). As in the case of Wyhl, it was not least this kind of patriarchal demeanour that annoyed the power plants' critics, who rightly continued to ask for the scientific basis of the proponents' arguments backing up the reactors, as long as the assessment of the situation in question was not available (WZ 1973d). The tone with which the pro-nuclear side countered the criticism of the wine-growers – which was indeed supported by science (WZ 1973f) – was certainly responsible at least in part for the cooling towers' critical reception. This can be deduced from the sarcastic style of a report in the

Mannheimer Morgen about a conversation with a member of the Ministry of Economics, who assured that "[o]n no account should one fear the effects that have been expressed in public, such as the formation of clouds that would eclipse the sun" (MM 1973).

Finally, the four 80-metre cooling towers for the two reactors were erected after an assessment by the German Weather Service had been finalised, with no fog or other negative impacts on the local climate deemed to be expectable (DE 1973b; SP 1973b). Nonetheless, the towers remained controversial and were taken up in discussions about the power plants time and again (SP 1973b; WZ 1974; MM 1974; cf. WZ 1975a). In 1975, after an expert assessment had demonstrated that there had, indeed, been no negative consequences for the local climate (DE 1975a), the question of cooling towers rose nonetheless to prominence once more when RWE announced its plan to build two additional reactors at the Biblis site (MM 1975a; cf. SP 1975). This time, the cooling towers were to be even larger (MM 1975b), as each new reactor was to be equipped with a "natural draft wet cooling tower" (DE 1975b) 160 metres high in the blueprints, with a diameter of 130 metres at the bottom and 86 metres at the top. While it knew that these dimensions would be criticised, RWE remained true to the patriarchal style it had adopted and pointed out that questions of "aesthetics" were "a matter of discretion" (MM 1975c).

In the end, the additional two reactors were never built. And even though their cooling towers were not the main reason behind the massive protests against the power plant's expansion, they and their feared environmental consequences were pointed out time and again when critique against the project was aired (MM 1975d, 1975e; WZ 1975b, 1975c, 1976; SP 1976; DE 1981b), and they definitely provided the critics with additional arguments (DE 1976, 1981a).

In other words, by the 1970s, the Rhine was far from being able to cool the industrial plants planned and built on its banks in Switzerland, France, and Germany while at the same time remaining a viable body of water. In order to turn it into an Atomic River and integrate it into the envirotechnical systems of new nuclear power plants, coordination was called for internationally, as well as on the federal level within Germany, resulting in requirements to reduce the river's utilisation as heat exchanger (at the expense of the surrounding atmosphere). For this purpose, large-scale cooling towers had to be built on its banks. Clearly, their visibility played a part in turning them into the target of protests, with the largest variants being put forward as horror scenarios. However, criticism was hardly limited to the size of the towers or their effect on the landscape. Their noise was also criticised, as were feared consequences for the local weather and climate. Once raised, the anti-cooling-tower protest was rather long-lived and persisted even when the plants were already in operation. It is highly plausible that the cooling towers' visibility, the fact that they were much more conspicuous than the reactors themselves, played a role in this. For the public, they added no positive value to the power plants. Rather, they seemed to be a permanent, widely visible reminder of the reactors and a source of new worries. At any rate, RWE later began to publish warnings about imminent start-ups of the cooling towers in local newspapers, including descriptions of the vapor that would become visible above them (*Bergsträßer Echo* 1984; MM 1989). The Biblis example has thus shown that criticism of nuclear power plants could be fuelled by their cooling system, with the visibility of the cooling towers in question being a central point of contention, beyond controversies regarding their environmental consequences.

4. Lingen: Accepting a Conspicuous Cooling System – With a Beach

In Lingen, in the Emsland District, near the border between Germany and the Netherlands, a demonstration power plant was operated from the late 1960s that combined a boiling water reactor and an oil-fired superheater. One decade on, it was shut down. At this point in time, there were discussions about erecting a new commercial nuclear power plant in its vicinity. In the end, it turned out to be one of the last three nuclear reactors to be built and operated in Germany. Similar to the one in Biblis, it was outfitted with a cooling tower – albeit one of the very type that had been broadly rejected in the Hessian town. In Lingen, too, the natural draft wet cooling tower about 150 metres high bred dispute. It was, however, only one part – and a small one at that – of the cooling system designed for the envirotechnical system that was to be the Emsland nuclear power plant. Its largest part, by far, was the "Geeste Reservoir," an artificial lake that was to be built about one dozen kilometres from the nuclear power plant itself. Its job was to regulate the Ems's water level, so that a nuclear power plant could be operated at all on this smaller river during the dry season.

Talks about the plans between utilities and Lower Saxony's administration had begun around 1970, concerning ways to modify the water level of the Ems by way of artificial reservoirs so that industrial plants and nuclear power plants could be operated along its banks when its waters ran low. During these talks, the administration had suggested building, instead of a number of smaller reservoirs preferred by the utilities, one large lake, fit for supplying water to cool numerous plants (*Lingener Tagespost* [LT] 1979c). This reservoir was publicly debated from late 1977 onwards, when RWE and the Vereinigte Elektrizitätswerke Westfalen (VEW) presented their plans to build four nuclear power plants in the Emsland from the 1980s onwards: two near Meppen, to be run by RWE, and two near Lingen, run by the VEW. To be able to operate these and to cope with their demand for one and a half cubic metres of cooling water per second each, the utilities also presented the plan for an artificial lake three and a half square kilometres in size, enclosed by dykes 20 metres high, holding 50 million cubic metres of water, said to be enough to operate the power plants for 140 days (LT 1977b, 1979i). From this lake, the water was to be reverted into the river when needed, enabling it to function as an Atomic River (LT 1979h; cf. *Meppener Tagespost* [MT] 1978a).

Initially, the plans for new nuclear power plants were received rather positively in Lingen and in the Emsland District to which it belonged (LT 1978a). There was, however, also some critique – and it was, not least, levelled at the proposed reservoir.

Elements of the plan for the artificial lake criticised immediately were the looming loss of forests, of farmland, and of "centuries-old farms" (LT 1977b; cf. Lingen City Council [LCC] 1980, TOP12). However, compensatory measures seemed sufficient to mitigate these arguments. Soon the lake was even considered to resuscitate Geeste's lost fishponds (LT 1977a). Additionally, it was valorised by adding a humid biotope that was to become home to birds and aquatic organisms (MT 1980; KLE-Blatt 1987).

A far more extensive debate was triggered by the reservoir's intended size. This moved to the centre of attention in the Emsland District during 1978. Soon, numerous societal and political actors demanded that the number of reactors planned had to be halved and the size of the lake reduced accordingly (LT 1978e, 1978i). Initially, the utilities, who still expected a rising demand for electricity, saw no point in this demand (LT 1978h). As they were confronted with a broad local alliance, however (LT 1979a, 1979b), they finally concurred and agreed to reduce the reservoir's size so that it would only be able to support two nuclear power plants. The VEW even began claiming that this had been its original intent, while the "authorities" had urged them to "think big" (LT 1979c). In May 1979, then, a concept for the smaller reservoir was presented (LT 1979f), with its water surface and height reduced by about one quarter (LT 1979g).

Besides the question of size, the safety of the planned reservoir was also an intensely important topic for the Emsland's public. The most prominent critics in this regard were, initially, the people from Geeste, which was to border directly on the artificial lake. Even back in 1977, local District Councillor Hermann Muke expressed his worries that a dyke breach could result in Geeste's annihilation (LT 1977b). With this worry, he was not alone. Many other inhabitants of Geeste, including its mayor, Johannes Over, shared them in some form or other (MT 1978a, 1978b), and similar fears were also present in other villages bordering on the planned reservoir (MT 1978c; LT 1979d, 1979e). After all, there had been dyke breaches, most famously at the new Elbe-Seitenkanal in 1976, but also elsewhere in Germany (Cf. Uekötter 2020, 192-209). The utilities, however, laboriously strove to allay those fears. Their experts explained in detail how each of the dyke breaches that were cited by worried citizens had occurred, and how similar problems were to be avoided here. They detailed their own plans and alternatives that had been considered, they pointed to similar projects in Germany or the Netherlands as examples of perfectly safe dykes, and offered to organise visits to the latter (MT 1978a; LT 1979e; for discarded variants, cf. LT 1978f, 1978g).

In the end, it was probably the combination of the project's downsizing and the fact that the utilities seemed to take local worries seriously that turned the tide in the councils of Geeste and Lingen. Majorities in both bodies accepted the plans for the reservoir in the early 1980s (MT 1982; LCC 1982, TOP8). Nonetheless, some critics remained opposed to the conspicuous, massive artificial lake.

The most outspoken of these were members of the Emsland's Greens. At the end of 1984, they brought the dispute to a climax. Not only did they try to stop its construction via the courts (LT 1984b, 1984c), but they also raised the accusation that tree stumps had been inserted into the dyke's body, endangering its stability in the long run. Construction works, they demanded, had to be halted, and finished parts opened up again and searched. Their accusations were mostly met with scepticism, however, and repudiated by those responsible for construction and oversight (LT 1984d, 1984e, 1984f, 1984g). They ultimately proved to have been baseless (LT 1984i), as did the prophecy of one of the Greens' councillors, who opined that the dyke would break, if not today, then "in 20 years" (LT 1984h). In fact, the reservoir took up its work during the summer of 1989, when its water was first used to modify the water level of the Ems to enable the new power plant to operate in spite of the river's "natural" water level falling below the necessary minimum (LCC 1989, TOP14).

Indeed, the Geeste Reservoir still exists today, while the Emsland nuclear power plant has been decommissioned due to Germany's nuclear phase-out. The artificial lake has even come to take up a central and positively regarded place in Geeste's environment. At least, it is very prominent among the pictures presented on the village's website and seems to have taken up a permanent place in its social life, with three clubs practicing and teaching diving, sailing, and surfing there (Gemeinde Geeste, n.d.).

Despite being very visible, then, the envirotechnical system designed to cool the Emsland nuclear power plant was ultimately accepted, independently from the atomic reactor itself. Unquestioningly, the compromises reached regarding its size and the promises kept regarding its safety were fundamental to this acceptance. Beyond that, however, the reservoir has been valorised successfully by providing it with additional functions beyond its role as part of the reactor's cooling system. Early on, demands had been made that the artificial lake should allow for recreational activities (LT 1977b, 1978b, 1978c, 1978d). These were then not limited to hiking routes along the dyke's crest (MT 1978a), but soon included variations of water sports. The reservoir was even endowed with its own, artificial sandy beach (LT 1984a). Thus, in other words, while its conspicuousness led to broad, loud, and long-lasting critique, the fact that it was turned into more than a part of a nuclear power plant's cooling system, endowed with additional benefits for the local population and the environment, paved the way for its broad and lasting acceptance.

5. Conclusion

In sum, then, the three examples demonstrate that utilities building nuclear power plants that depended on artificially improving the cooling capacity of the rivers on which they were built, thereby transforming them into Atomic Rivers, performed technical interventions that turned the rivers in question into parts of envirotechnical systems, which created (additional) reasons for resistance against the reactors' construction. In Oldbury, this resistance was initially rather high. Once the tidal reservoir took shape, however, it came to be widely accepted. After all, it was not even visible all of the time. In Biblis, strong protest was evoked by cooling towers because of suspected negative consequences for the local climate and because of their visible impact on the landscape. The first argument was soon refuted by studies, while the latter gained in importance when, beyond the first two reactors, two additional ones were to be constructed, equipped with large-scale cooling towers. Even though those were not constructed in the end, the existing, smaller-scale cooling towers remained contested throughout, provoking critique and worries – visible in RWE's practice of warning ahead of them becoming operational. In Lingen, finally, a cooling tower of the dimensions feared in Biblis was indeed built. However, it was only a small part of the power plant's cooling system. The largest element of it was the Geeste reservoir, which, indeed, drew the most intense protest of all the cooling systems analysed here. It even gave rise to rather shady political manoeuvres. That notwithstanding, it was accepted in the end, and even separately from the nuclear power plant – not least because it had been endowed with additional functions. It was combined with a biotope and served as a water sport facility. Clearly, then, the more visible the respective intervention in the fluvial landscapes was, the fiercer the resistance. On the other hand, additional benefits associated with such interventions – especially environmental ones and those regarding their recreational usability – offered a way to overcome this resistance and turn the mere cooling systems into elements of their locales that could well be accepted as cool, even independently from the reactors. The reception of an envirotechnical system and its eventual rejection or acceptance (or even appreciation) was contingent upon more than its (blended) biological and technical components "as such." It was deeply contingent upon the way those were charged with meaning by and for the local communities.

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