ETH Zurich Department of Architecture
ARCHITECTURE OF TERRITORY
Chair of Architecture
and Territorial Planning
Professor Milica Topalović

Kraftwerk Schweiz
Spring 2024

Hydro

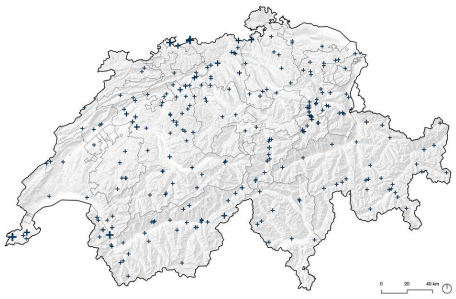
Repairing the Heritage of Hydropower in Switzerland

Lisa Müller and Cyrill Ender

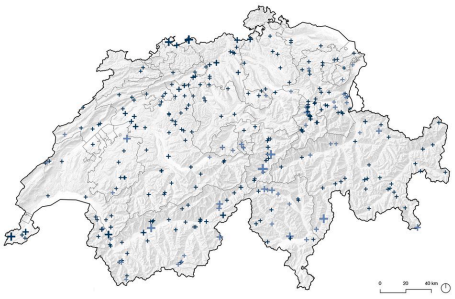
Switzerland, known as the water castle of Europe, has a 5,000 year old hydropower history. Throughout the years, many different hydropower landscapes have formed creating a multitude of heritages. The most important once being: ecological, social and infrastructural heritage. In the following reportage those three heritages are looked at based on three different case studies.

Energizing Heritage: The Role of Hydropower in Switzerland

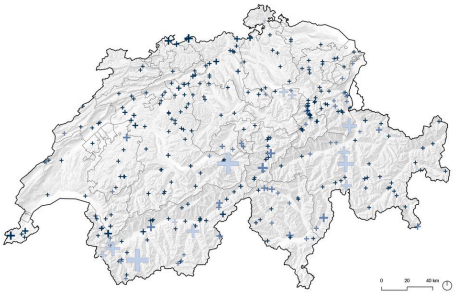
Hydropower being one of the oldest and most important energy sources in Switzerland accounts for 58.9% of the domestic electricity production. These 58.9% are generated by 1’650 hydropower plants located throughout Switzerland, from which 650 have an output greater than 300kW. However, even though hydropower accounts for the largest share of electricity produced in Switzerland, it still has the potential to grow by between 3 and 7%. In order to exploit this potential, the government has planned 40 new large hydropower projects. If all of these 40 projects were to be implemented and generate the planned output, they would increase domestic production of hydropower by 5.8%.



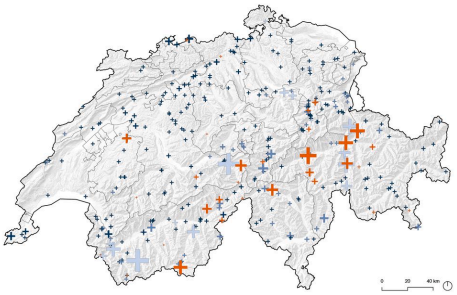
Location of all run-of-river hydropower plants (dark blue). The bigger the plus the greater the output. Source: Swisstopo, 2024.



Location of all run-of-river (dark blue) and storage (medium blue) hydropower plants. The bigger the plus the greater the output. Source: Swisstopo, 2024.

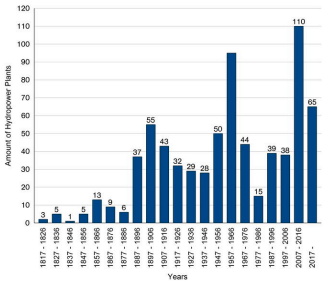


Location of all run-of-river (dark blue) and storage (medium blue) and pumped storage (light blue) hydropower plants. The bigger the plus the greater the output. Source: Swisstopo, 2024.

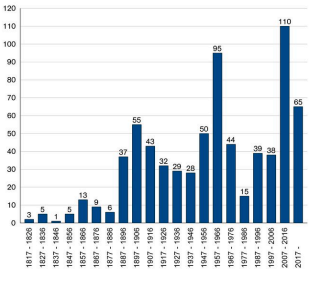


Location of all hydropower plants including the 40 planned hydropower projects

There are three different types of hydropower plants. The most significant in terms of power production is the run-of-river hydropower plant, which accounts for 48.4% of domestic electricity produced by hydropower plants and can be found throughout Switzerland. The second type is storage hydropower, accounting for 47.4% of production and primarily located in alpine areas. Pumped storage hydropower plants, also mainly found in alpine areas, contribute 4.2% of production. The accompanying maps show the locations of all existing hydropower plants, sorted by type and power output, with larger symbols indicating greater output.

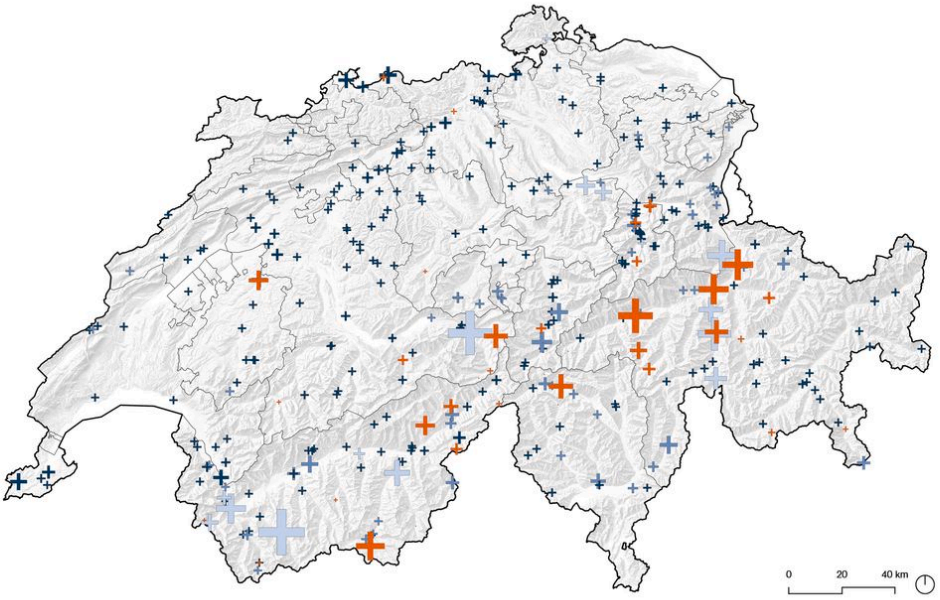


Hydropower Building Peak. Source: QGIS



Hydropower Building Peak. Source: QGIS

Historically, there have been three peaks in the construction of hydropower plants, usually occurring during renewable energy debates or following a world war, with the aim of increasing energy independence.



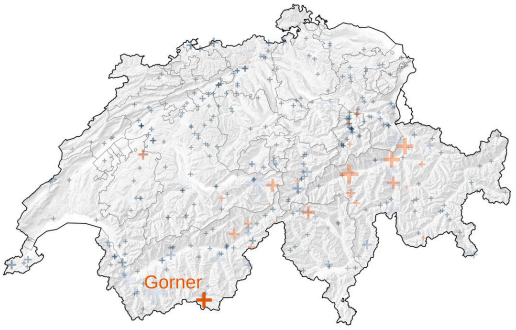
Location of all hydropower plants (blue) including the 40 planned hydropower projects (orange). all run-of-river (dark blue) and storage (medium blue) Source: Swisstopo, 2024.

In line with the current goal of expanding renewable energy usage, the government has planned 40 new hydropower projects, all of which are either storage or pumped storage plants located in the Alps. These projects aim to store energy from other renewable sources to reduce electricity fluctuation.

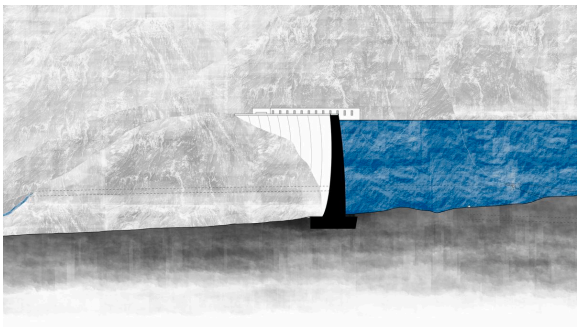
Given the significant environmental impacts of hydropower landscapes, which are not necessarily positive, a closer examination of how to mitigate these effects is warranted. This involves addressing the social, environmental, and infrastructural impacts that hydropower plants have had or will have. Since these impacts vary from plant to plant, it is crucial to assess each hydropower plant individually rather than generalizing. To illustrate possible approaches to dealing with these impacts, three case studies have been selected, each exemplifying one aspect of social, environmental, or infrastructural heritage, thereby providing insights into better understanding and managing hydropower.

Balancing Ecological Heritage: The Gornerli Project

Our first case study examines one of the 40 planned hydropower projects: the Gornerli project, a new storage hydropower plant near Zermatt by the Gorner Glacier. Due to glacial melting, the glacier is retreating from its valley, creating an ideal location for a new hydro dam. Due to the great environmental impact the realisation of the hydropower plant would have, this chapter adresses the repair of ecological heritage.

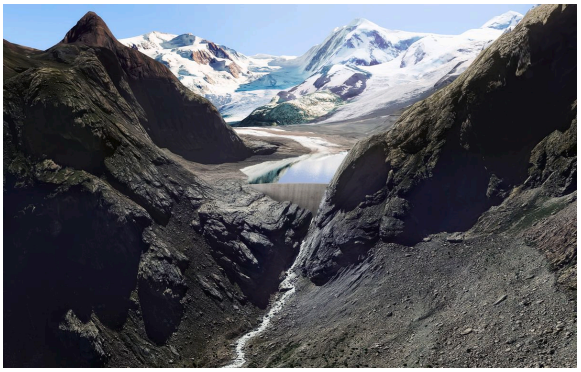


Location of the planned Gorner hydropower plant in Switzerland

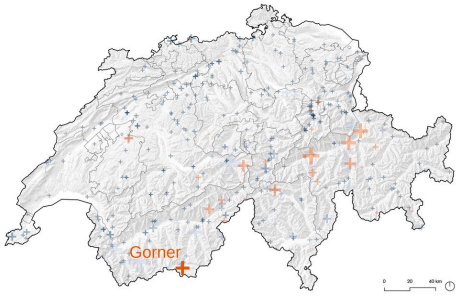


Section of the planned storage hydropower plant Gorner

Gorner glacier valley. Source: https://vokuhila-mag.ch/zwischen-stauen-und-schuetzen/ [https://vokuhila-mag.ch/zwischen-stauen-und-schuetzen/], 2024.



Visualization Gorner glacier valley with dam. Source: https://www.nzz.ch/schweiz/neuer-stausee-im-wallis-soll-stromknappheit-im-winter-verringern-ld.1663691 [https://www.nzz.ch/schweiz/neuer-stausee-im-wallis-soll-stromknappheit-im-winter-verringern-ld.1663691], 2024.

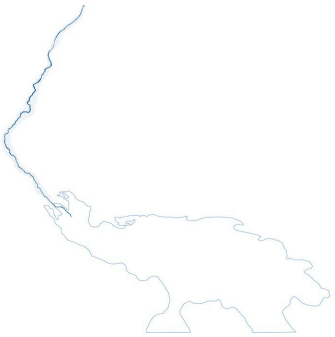


Location of the planned hydropower plant Gorner in Switzerland. Source: Swisstopo, 2024.

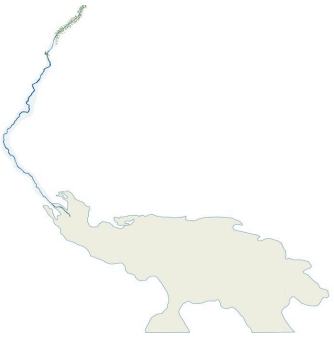
Given the high likelihood of this project's implementation, we have investigated its potential consequences.

Picture of first consequence: Zermatt being flooded due to glacier melting

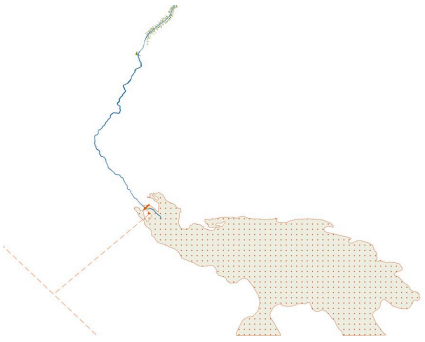
Picture of second consequence: A glacier valley where a new ecosystem has formed



Schematic map of the Groner glacier and the river Gornera. Source: Swisstopo, 2024.



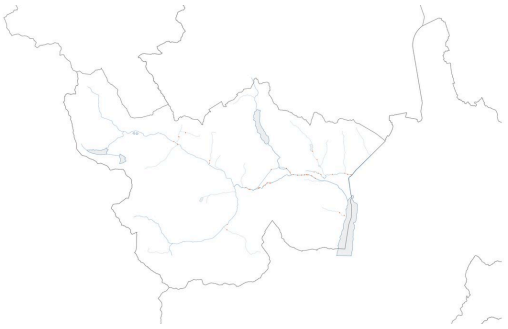
Schematic map of the Groner glacier ecosystem and the flooded houses due to the river Gornera. Source: Swisstopo, 2024.



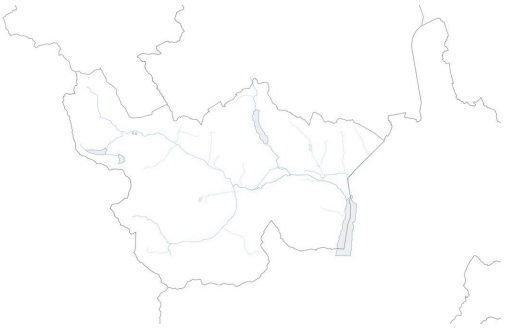
Schematic map of the Groner energy layer. Source: Swisstopo, 2024.

Two major consequences have been identified. First, the implementation of the dam would benefit Zermatt by providing significant flood control. In recent years, Zermatt has faced severe flooding issues due to glacial melting, leading to widespread support for the project, as expressed by the community president. Second, despite the benefits to Zermatt, the construction of this large-scale storage hydropower plant would result in the destruction of a potentially important ecosystem. Opponents argue that glacier valleys are fertile grounds for new ecosystems specific to glacial environments, and destroying them for energy infrastructure would be a significant loss.

A map summarizing this case study would show the Gorner Glacier and the Gornera River, which flows from the glacier, in blue. The houses in Zermatt affected by floods and the potential ecosystem would be indicated in green, while the energy intervention in the landscape would be marked in orange. This visual representation highlights that the greatest impact of the Gornerli project would be environmental, with positive implications for flood control in Zermatt and negative implications due to the loss of a potential ecosystem.

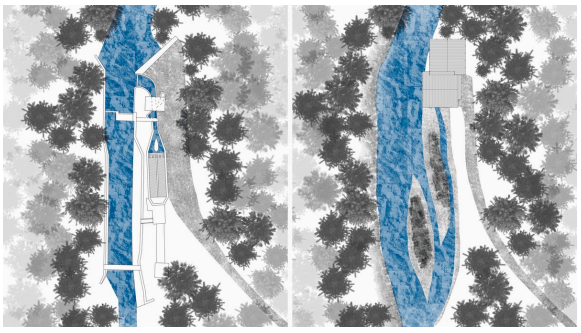


Schematic map of the canton of Glarus with the rivers and small scale power plants. Source: Swisstopo, 2024.

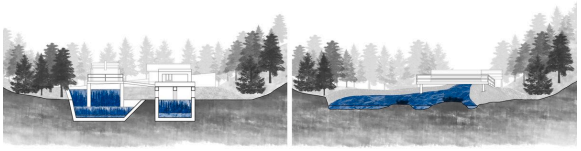


Schematic map of the canton of Glarus with the rivers and after the decommissioning of the 37 small scale power plants. Source: Swisstopo, 2024.

Recognizing the significant ecological impact that the Gorner hydro plant would have, we reached out to Boris Previšić to examine his proposal for decommissioning hydropower plants. Previšić's proposal advocates for the removal of small-scale hydropower plants in the canton of Glarus to restore their former ecosystems. Our suggestion, based on this specific case study, is that it is reasonable to consider this approach. This proposal includes the decommissioning of 37 small-scale hydropower plants, one of which is “Kraftwerk Tschudibergbach” located in the southern part of the canton.



Floor plan of the planned decommissioning of the hydropower plant Tschudibachberg



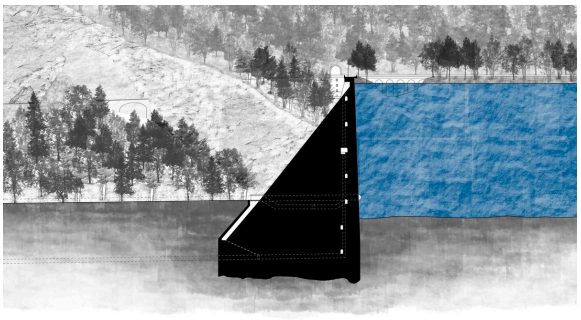
Section of the planned decommissioning of the hydropower plant Tschudibachberg

The visual representation of the current situation compared to the post-decommissioning scenario illustrates that while one bio-habitat would be lost, 37 could be restored. Importantly, this restoration would not result in a reduction in power production, as the combined output of the 37 small-scale plants is only one-third of what the new Gorner storage hydropower plant would produce.

Power to the People of Wägital: From Historical Displacement to Heimfall Empowerment

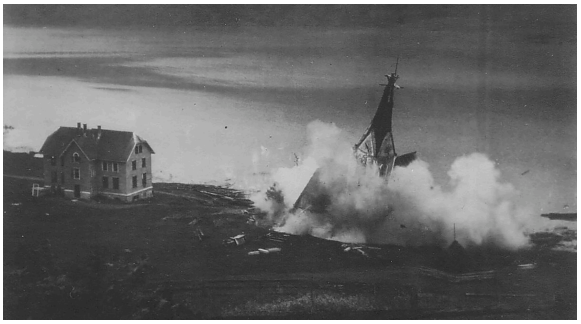
Our second case study focuses on the Wägital pumped storage hydropower plant, located in the foothills of the Alps in the canton of Schwyz. This case study will examine the social heritage of Wägital. Constructed in 1924, Wägital has a history marked by brutal construction practices, which is why this chapter adresses how to repair social heritage.

Location of the Wägital
hydropower plant in Switzerland



Section of the pumped storage
hydropower plant Wägital

Picture of the village Innerthal
before it was demolished



Picture of the village Innerthal
while it was demolished

Picture of the village Innerthal
after it was demolished

Location of the hydropower plant Wägital
in Switzerland. Source: Swisstopo, 2024.

During the hydropower expansion 100 years ago, the displacement of communities for the perceived greater good was unquestioned, leaving the displaced with little hope for a better future. To minimize the symbolic martyrdom of the submerged civilization, the entire village of Innerthal was demolished. Although residents received some compensation for leaving their homes, it was insufficient to heal the trauma of displacement. Many residents stayed as long as they could, even if it meant wading through knee-deep water. The dire economic conditions forced them to leave, as wealthy cooperatives faced little opposition, and dissenters were easily bought off.

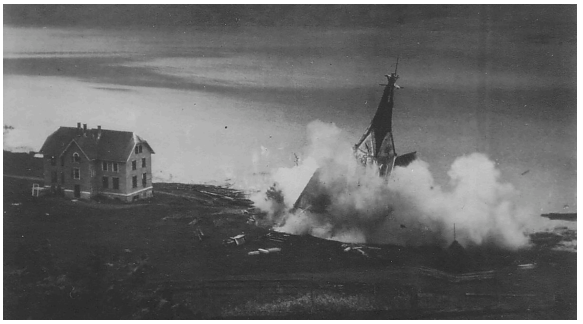
Map showing the location of all flooded villages in Switzerland

Map showing the location of all flooded villages in Switzerland. Source: Swisstopo, 2024.

Picture of the village Marmorera a sunken village. Source: EWZ; Schmidli, Photopress Archiv, 2024.

Picture of the village Marmorera a sunken village. Source: https://www.swissinfo.ch/ger/kultur/als-der-hunger-nach-energie-ganze-doerfer-frass/47884582 [https://www.swissinfo.ch/ger/kultur/als-der-hunger-nach-energie-ganze-doerfer-frass/47884582], 2024.

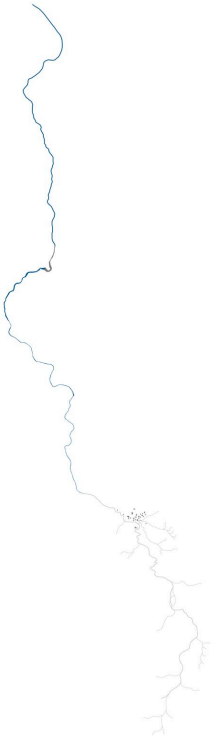
Picture of the village Innerthal before it was demolished. Source: https://www.obersee-nachrichten.ch/zeitung/publizierte-news/2054-kanton-sucht-bild-und-tonsch%C3%A4tze [https://www.obersee-nachrichten.ch/zeitung/publizierte-news/2054-kanton-sucht-bild-und-tonsch%C3%A4tze], 2024.



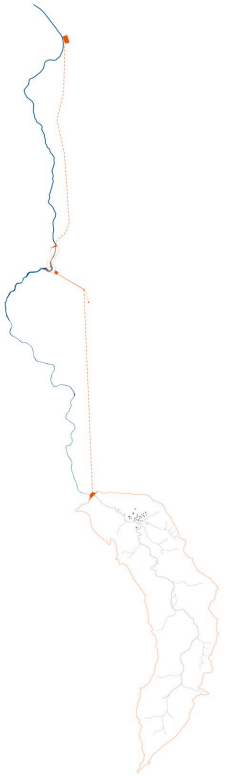
Picture of the village Innerthal while it was demolished. Source: https://blog.nationalmuseum.ch/2020/08/stausee-flutet-dorf/ [https://blog.nationalmuseum.ch/2020/08/stausee-flutet-dorf/], 2024.

Picture of the village Innerthal after it was demolished. Source: Walter Mittelholzer, 1937.

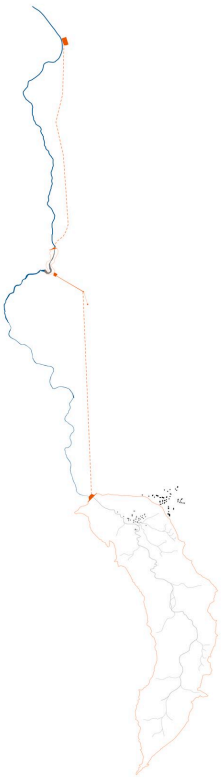
Wägital shared its fate with seven other villages, now remembered only as lakes: Sihlsee, Schiffenensee, Göscheneralpsee, Zervreilasee, Lai da Marmorera, Lago di Vogorno, and Lac d'Emosson. These are some images of another submerged village, Marmorera.



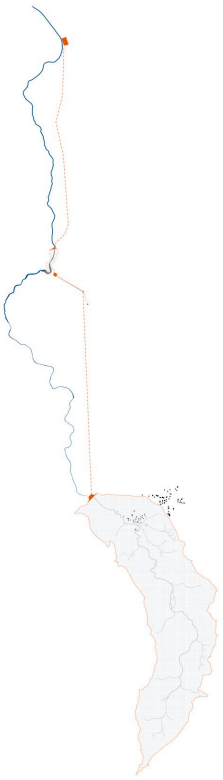
Schematic map of Wägital showing the original situation. Source: Swisstopo, 2024.



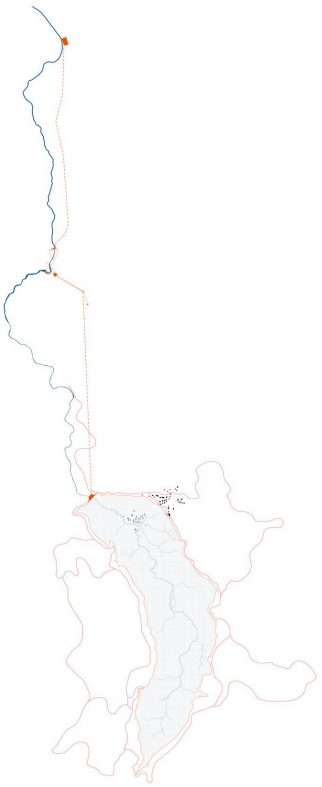
Schematic map of Wägital showing the energy layer. Source: Swisstopo, 2024.



Schematic map of Wägital showing the new village Innerthal. Source: Swisstopo, 2024.



Schematic map of Wägital showing the flooding of the wägitalersee. Source: Swisstopo, 2024.

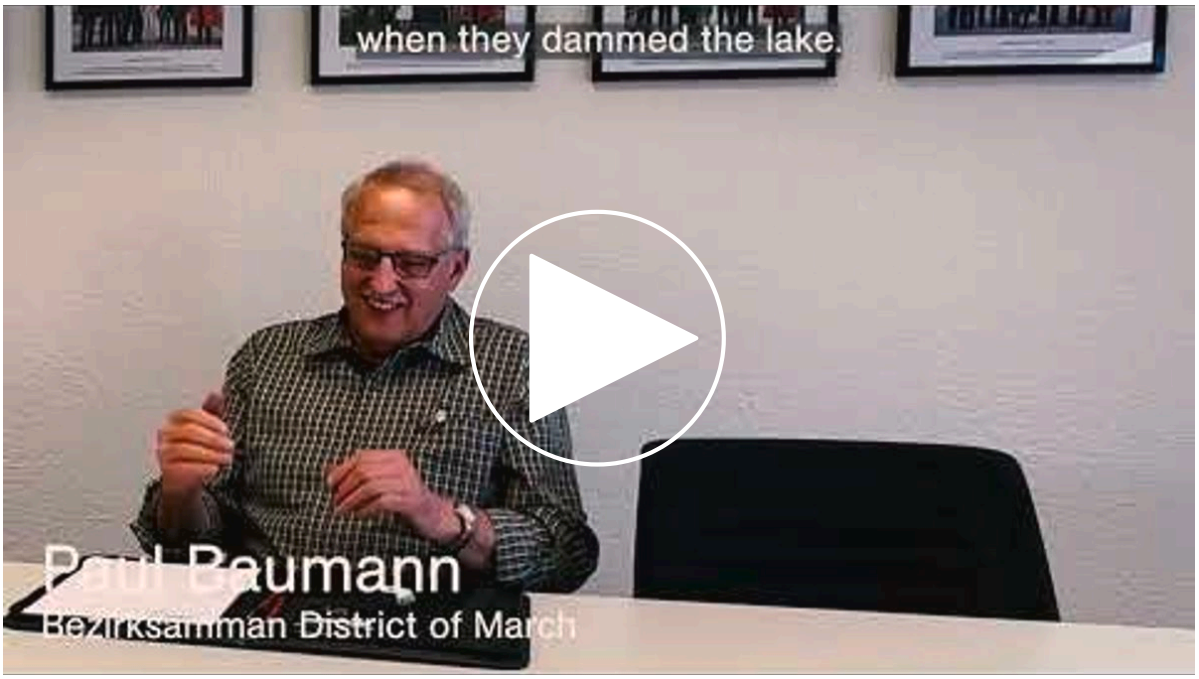


Schematic map of Wägital showing the new local recreation layer. Source: Swisstopo, 2024.

Despite its tragic history, Wägital reinvented itself, and a new “ecosystem” emerged from the hydropower landscape. Over the years, the reservoir became a popular tourist destination, fostering a sense of pride among the locals.

Considering this history, it is noteworthy that for the past 100 years, Wägital has been jointly owned by EWZ and AXPO, with the current concession ending in 2040. Of the 129 GWh of energy produced annually, only a minuscule 0.3 GWh is donated to the district hospital in Lachen. Another form of compensation for the community is the annual water interest paid by the plant operators, which, according to a district council member, amounts to over 2 million Swiss francs. Although this may seem substantial, these figures are outdated and inadequate by today’s financial standards.

Given that the social impact of Wägital’s construction was profound, bordering on colonialism in terms of displacement, our proposal for reparations lies in the democratization of the hydropower sector. A significant part of this involves renegotiating the upcoming concession to ensure fairer terms for the affected community.



https://youtu.be/miB3F_ezwrg

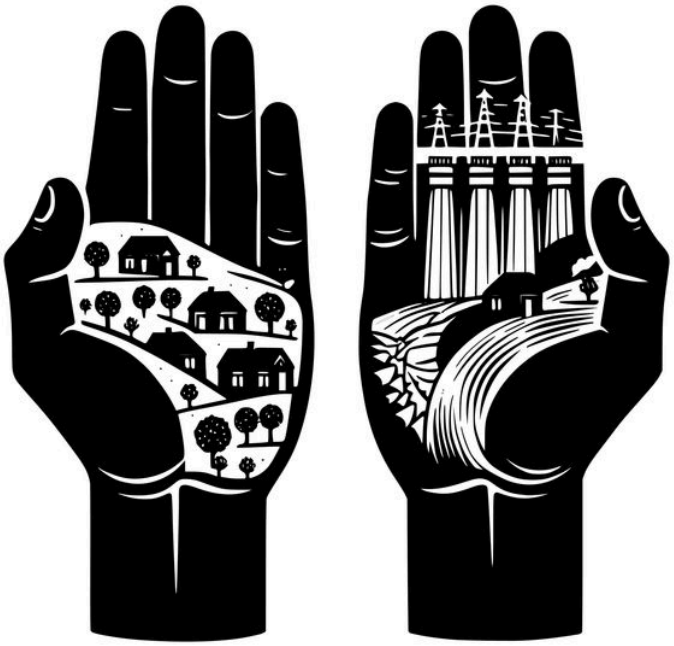
The video highlights that in the case of Wägital, the local government is planning to renegotiate the concession with EWZ and Axpo. However, this is not their only option. If renegotiations do not proceed as planned, the local community can invoke “Heimfall,” whereby they decide to run the hydropower plant themselves instead of re-letting it to a power company.

Map showing the location of all places where concessions will end in Switzerland. The lighter the blue the sooner the concession ends. Source: Swisstopo, 2024.

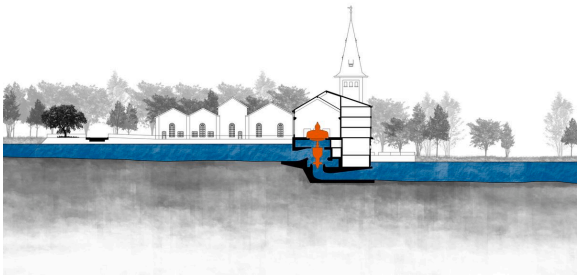
Wägital is not the only location facing an expiring concession. Throughout Switzerland, there are 26 places where concessions are due to expire within the next 35 years. This map shows these locations, with darker symbols indicating later expiration dates.

Another example is the village of Surses, with the Lai de Marmorera hydropower plant. In this case, the local community has chosen not to re-let the hydropower plant and to let it fall under local control, demonstrating that the end of a concession is not only about negotiating better terms but also about seeking justice and regaining control over decisions made a century ago.

Infrastructural Heritage: Preserving Aarau's Hydropower Legacy



Our third and final case study concerns a run-of-river hydropower plant located in Aarau, on the border between the cantons of Aargau and Solothurn. Despite human intervention reshaping the energy landscape within the floodplain, the area has since recovered and reorganized, establishing a symbiotic relationship between energy production, the local community, and the ecosystem. This chapter addresses the how to repair infrastructural heritage.

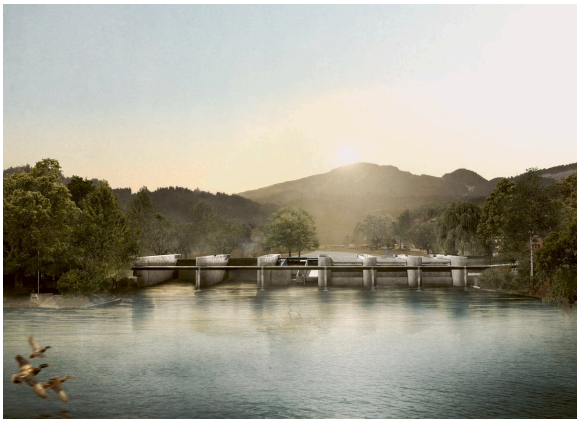


Section of the run-of-river hydropower plant Aarau

Location of the hydropower plant Aarau in Switzerland. Source: Swisstopo, 2024.

Commissioned in 1894, this plant has a long and rich history. Unlike Wägital, its history is less marked by brutality; however, the local community is currently mobilizing to oppose the renovation plans of the local power company, ENIWA. This opposition has sparked media coverage, highlighting the friction between the community and the power company.

Picture of the current hydropower plant in Aarau. Source: https://www.wasserkraft-aarau.ch/wasserkraftwerk-aarau-1 [https://www.wasserkraft-aarau.ch/wasserkraftwerk-aarau-1], 2024.

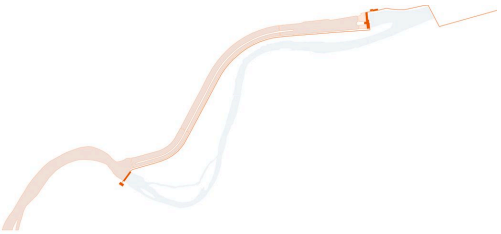


Visualisation of the planned hydropower plant in Aarau. Source: https://www.wasserkraft-aarau.ch/das-projekt [https://www.wasserkraft-aarau.ch/das-projekt], 2024.

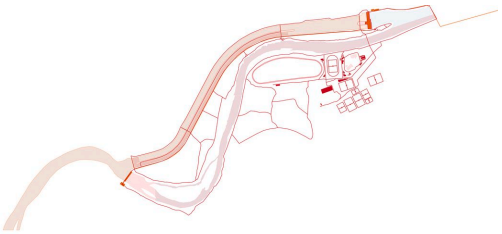
https://youtu.be/hy-HJdN5Xaw

Leo Keller, a local citizen, is displeased with the latest developments regarding the hydropower plant. ENIWA, the company that owns the plant, has submitted renovation plans to increase production by 23%, raising the annual energy output from 101 GWh to 124 GWh. The proposal includes demolishing the “Middle Dam,” which would significantly disrupt the ecosystem. In response, ENIWA has planned 59 compensatory measures, including the creation of a new, human-free reservoir for animals. Another consequence of removing the “Middle Dam” would be a doubling of the residual water flow in the old Aare river course. ENIWA, which is 95.4% owned by the city of Aarau, has also published visualizations of the proposed new hydropower plant, showing the current status and the expected post-implementation changes.

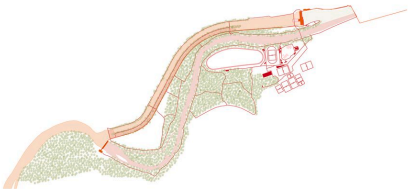
Schematic map of the river Aare. Source: Swisstopo, 2024.



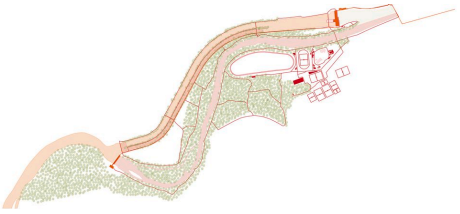
Schematic map of the energy layer in Aarau. Source: Swisstopo, 2024.



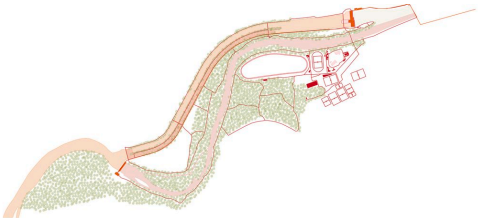
Schematic map of the local recreation layer in Aarau. Source: Swisstopo, 2024.



Schematic map of the ecology layer in Aarau. Source: Swisstopo, 2024.

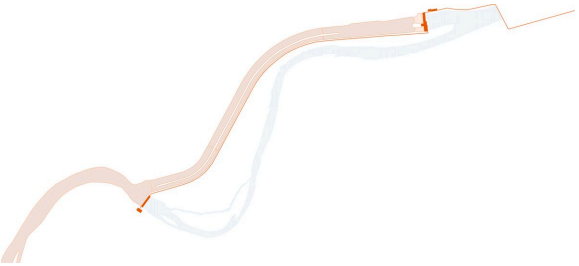


Schematic map of the ecology layer in Aarau. Source: Swisstopo, 2024.

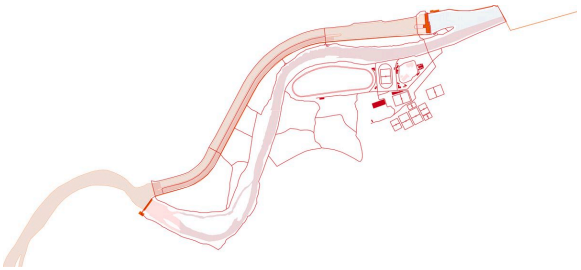


Schematic map of the ecology layer in Aarau. Source: Swisstopo, 2024.

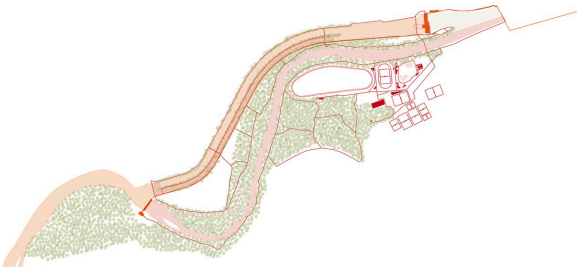
Schematic map of the river Aare. Source: Swisstopo, 2024.



Schematic map of the energy layer in Aarau. Source: Swisstopo, 2024.



Schematic map of the local recreation layer in Aarau. Source: Swisstopo, 2024.



Schematic map of the ecology layer in Aarau. Source: Swisstopo, 2024.

In the case of Aarau, we agree with Leo that the hydropower plant represents a harmonious coexistence of energy production, community, and ecosystem. Although the landscape was man-made in the 19th century, it has since evolved to acquire many valuable qualities. The energy structure in the Aare is protected in its entirety, making the plant one of Aarau's few industrial monuments and a visual reminder of the origins of electricity. In addition to its significance as an energy and infrastructural asset, the Aare has long served as a vital local recreation area. In the 1930s, there was a popular Aare bath next to the power plant, and people still frequent the area to walk, cycle, swim, paddle, meet, or simply relax and read. Both courses of the Aare support a rich ecosystem where humans, animals, and plants coexist. The diverse aquatic landscapes host a wide range of wildlife, from microscopic larvae to shy birds like the kingfisher and mammals such as the beaver.

Examining all three maps simultaneously, it becomes clear that the layers of energy production, community, and ecosystem are closely intertwined. For this reason, our proposal for preserving the heritage of Aarau's hydropower plant is to do nothing and embrace the natural development that has occurred over time.

ACKNOWLEDGEMENTS

Thank you to everyone who took the time to talk to us, especially Hans-Kaspar Scherrer, Hansjürg Tschannen, Leo Keller, Walter Kälin and Paul Baumann.

SOURCES

- Axpo holding. “Künftige Elektroingenieure erleben im Kraftwerk Wägital, dass zuverlässige Systeme von höchster Qualität selbst nach einem Jahrhundert wichtige Erfolgsfaktoren sind. Denn: Die einfachste, sicherste und sauberste Art der Stromproduktion ist und bleibt die Wasserkraft.” Axpo website. https://www.axpo.com/ch/de/knowledge/magazin/innovationsmanagement/Erstes-Partnerwerk-der-Schweiz.html
- David Vonplon, Erich Aschwanden. “Alpenforscher verteidigt Solarkraftwerke: «Wer sagt mir, dass nicht auch eine Kuh die Alpen verunstaltet?».” NZZ online 07 Ferbruary 2024. https://www.nzz.ch/schweiz/sprengt-die-daemme-der-flusswasserkraftwerke-ld.1777184
- ENIWA. “Ein Projekt über die Kantonsgrenzen hinweg.” online 2021. https://www.wasserkraft-aarau.ch/das-projekt
- ENIWA. “Wasserkraft in Aarau.” online 2021. https://www.wasserkraft-aarau.ch/
- ENIWA. “Wasserkraft.” online 2024. https://www.eniwa.ch/de/wasserkraft.html
- Graf Harry. “125 Jahre ewz – weitere 125 Jahre Innovation.” EWZ website online 15 August 2017. https://www.ewz.ch/de/ueber-ewz/newsroom/medienmitteilungen/125jahre.html
- Grande Dixence. “MEHRZWECKSPEICHER GORNERLI.” Grande Dixence website online December 2023. https://www.grande-dixence.ch/de/mehrzweckspeicher-gornerli-1925/
- Keller, Heiner. Aarau, der Stadtbach und die Aare. Aarau: ANL AG, 2014.
- Kleinwasserkraft Glarnerland. Website. https://www.kleinwasserkraft-gl.ch/kraftwerke
- Oswald Marie. “ewz wird der Gemeinde Surses und dem Kanton Graubünden ein Angebot für eine neue Konzessionierung unterbreiten.” EWZ website online 21 January 2024. https://www.ewz.ch/de/ueber-ewz/newsroom/medienmitteilungen/2024/Angebot_Rekonzessionierung_Tinizong_Nandro.html
- SDA. “Surses erteilt EWZ klare Abfuhr.” Tagesanzeiger Zurich online 21 January 2024. https://www.tagesanzeiger.ch/zuercher-kraftwerke-in-graubuenden-surses-erteilt-ewz-klare-abfuhr-786848729374
- SRF. “Stausee-Projekt Gorner.” SRF 10 vor 10 online 27 July 2023. https://www.srf.ch/play/tv/10-vor-10/video/stausee-projekt-gorner?urn=urn:srf:video:4f792170-eeac-4967-86f3-8279039b6004
- Swiss Federal Office of Energy. bfe admin online 02 May 2024. https://www.bfe.admin.ch/bfe/en/home/supply/renewable-energy/hydropower.html/

Architecture of Territory
Professor Milica Topalović

TEACHING TEAM
Dorothee Hahn
Milica Topalović
Jakob Walter
Jan Westerheide

Prof. Milica Topalović
ETH Zurich
ONA G41
Neunbrunnenstrasse 50
8093 Zurich
Switzerland
+41 (0)44 633 86 88
www.topalovic.arch.ethz.ch