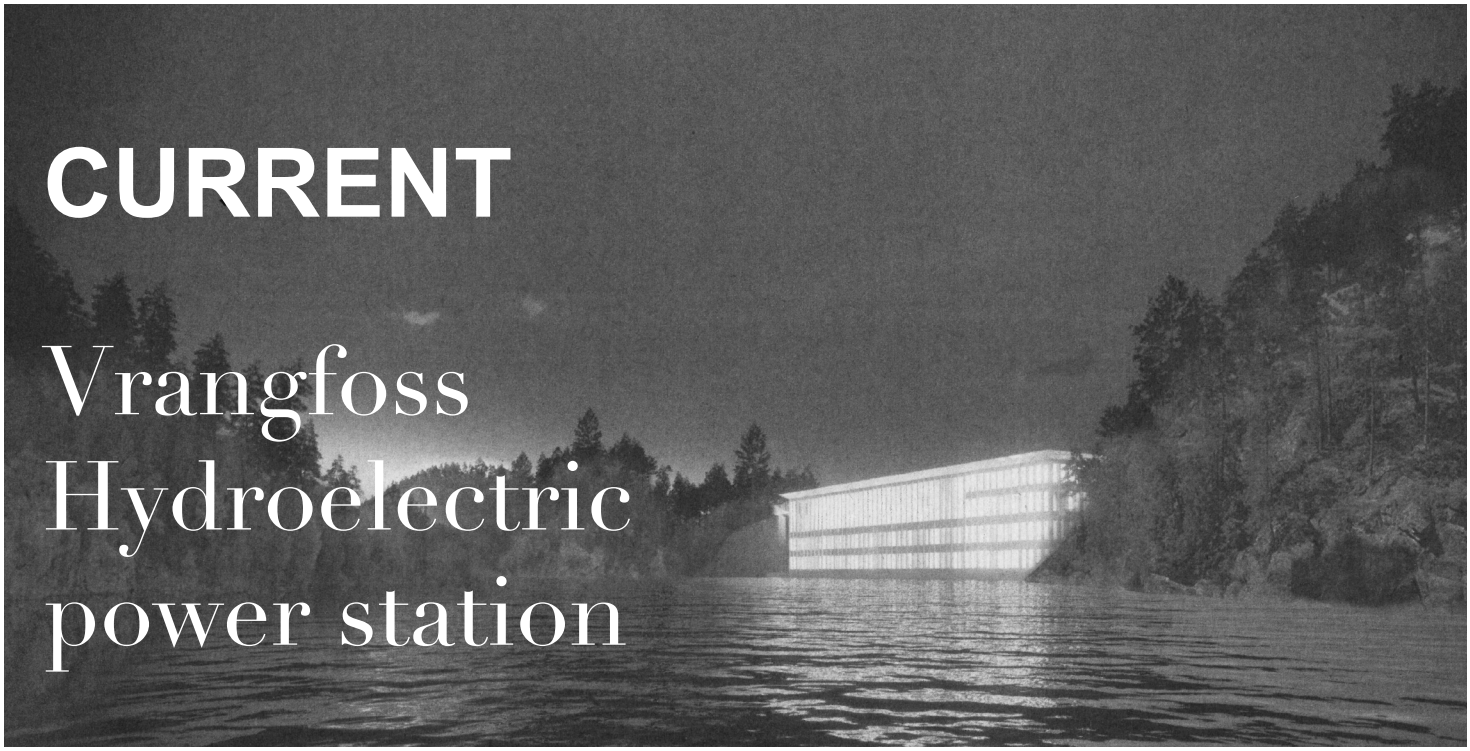


CURRENT

Vrangfoss Hydroelectric power station

The global demand for electricity is increasing. It is estimated that the global consumption of electricity will grow by almost 80% by the year 2050[1]. While new technologies for power production are being developed to replace fossil fuels, hydro power is a tried and tested way of producing electricity without CO_2-emissions. However, hydro power is known to take its toll on it's local environment. Through damming up water, blasting rock, and poring enormous amounts of concrete, hydro power is an often controversial endeavour[2]. This projects seeks to utilise an already existing infrastructure, by adding a new power station of a series of three others. By adding to a node in the grid, rather than to create a new node in the grid, this projects aims to take advantage of an already adapted nature rather than to go in and alter a pristine site.

The fundamental elements of hydro power production is simple. Water is dammed up to provide a steady and foreseeable battery of potential energy in the dam. This potential energy is then turned into kinetic energy by a controlled inlet of water through the sluices and into the penstocks and then through the turbines. As the water sets the turbines spinning, the kinetic energy of the flowing water is converted into mechanical energy in the spinning turbines and generators. The mechanical energy is then converted into electrical energy through induction in the generators, and sent out to the grid. A fascinating aspect of this is that, due to the laws of thermo dynamics, the force of an accelerating electric car can be no less than the force of water flowing though the turbines at the power station. In lieu of this, the power station becomes the place where the forces of nature are translated into the forces that facilitates our everyday lives.

Still, the means of production of electricity is becoming more and more hidden away while its consumption and ubiquity is growing. This project aims to create a hydro station with a strong presence and clarity, mediating the forces and scale of nature, as well as the forces and scale of machines.

The project is a new hydro station at Vrangfoss, in the river Glomma, the largest river in Norway. The site sits within an exisiting infrastructure for hydro power, and the project is the fourth hydro station over a 15 km run of the river, starting at Solbergfoss hydro station, passing Kykkelsrud station, and ending at Vamma station. Over this distance, the river falls over 60 meters, and most of it is dammed to be controlled by the stations, but there is still one waterfall left, squeezed in between Kykkelsrud and Vamma power stations.

Vrangfoss is one of the narrowest points in Glomma, with a water flow of more than 3000 cubic meters of water pr. second running over a 7 meter natural water fall. By damming up the water at this narrow point, the water level is set 5 meters higher than today's average, to build pressure, and to allow control of the flow through the dam and into the turbines.

The river is led into the turbines through four openings in the dam. The turbines are Kaplan turbines, a type of turbine optimized for large flow and low head*. The flowing water sets the turbine spinning, and exits through four draft tubes, and into the river immediately down stream of the dam.

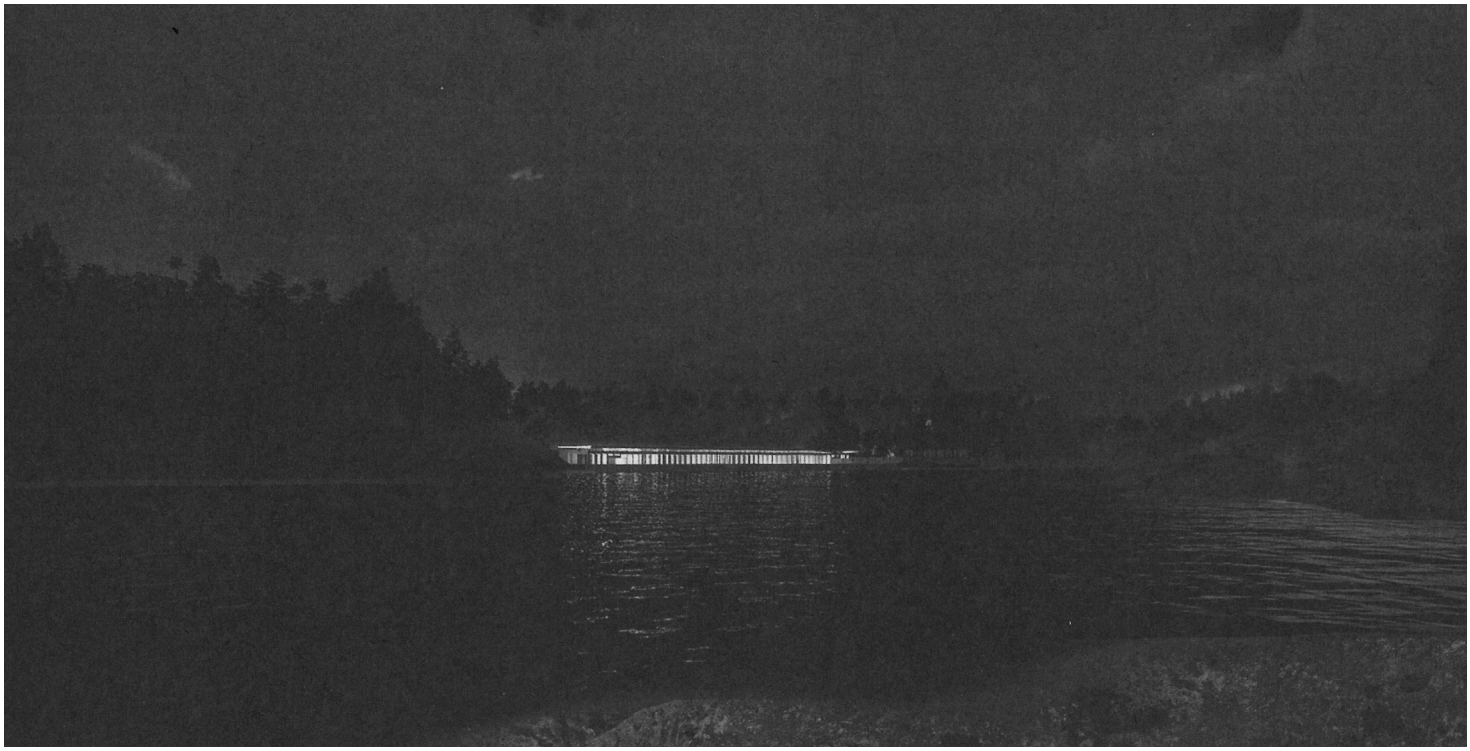
The spinning turbines drives the generator which is a large wheel of electro magnets surrounded by spools of copper wire. This in turn generates electricity which is taken out of the station to a substation, and from there led to the substation at Kykkelsrud power station to be directed to the consumers through the electrical grid.

The station building itself, the power house, is built on a platform in front of the dam, around the turbines and generators. This four storey building is accessed from atop the dam itself though bridges spanning the void between the dam and the building, or through a tunnel coming from higher in the landscape, accessed from the road to the station. The building is constructed of two large cores for water, sewage and vertical communication, as well as four cylindrical concrete structures supporting the generators and the concrete floors of the station. The envelope of the building consists of concrete columns placed at 1,5 meter intervals, supporting the large, brushed aluminium clad roof, together with the two cores. Between each column are windows and low walls.

**Head is the term used for the distance the water falls from the surface to the turbine.*

1 https://www.power-eng.com/2019/09/24/global-electricity-consumption-to-rise-79-percent-higher-by-2050-eia-says/#gref

2 https://snl.no/Alta-saken



The station peeking over the top of the dam

The inspiration for this project grew from an interest in nature and architecture, and the way certain projects appear almost as modified natures in themselves. Growing up in a rural town in Norway, the largest buildings around were the hydro stations. Although far away from the town centre, the sheer sizes of these buildings made them seem almost urban in themselves, surrounded by forests and fields. This experience, the realisation that the biggest buildings around were so different and so much more massive than anything else, and that they existed only to create electricity has made a deep impression on me. Today, most new power stations are hidden away deep inside mountain halls, or built as anonymous additions to already existing buildings. Any addition made to the electrical grid and infrastructure only becomes visible through the occasional construction of new power lines spanning between the cities. This, combined with the growing use of wireless charging and longer lasting batteries makes the physical manifestation of the production of electricity less and less obvious. This project aims to create a building that does not hide nor boast, but clearly signals that the production of electricity is an important endeavour that takes its toll on its surroundings.

Most Norwegian power stations are situated far away from ordinary life, and as mentioned earlier, often hidden away. This makes the impact of the discovery of these places even stronger. The realisation that these massive buildings are out there, constantly humming with the force generated inside, is an experience enhanced by the approach through the landscape. At Vrangfoss, the light from the station hints at it's location from far away. As one comes closer, it is evident that this is not a trivial place. The first thing one arrives to, coming from the west side is what appears to be a lake, as the dam holds back the water. Looking south, the light from the power station creates a strong line in the landscape where one would expect to see a beach. Walking closer to it, along the shore of the lake, the landscape hides the station, and the first thing one arrives to is the supporting sluices. Crossing over the bridge, one will see the water being held back by the great iron gates operated by the small sluice house at the middle of the bridge. Walking around the small hill, the light from the power station comes through the trees, and the sound from the rushing water becomes stronger. As one sets foot on the dam, the power becomes evident through the vibrations coming through the concrete. The building is very close to the dam, but separated from it, as understood by the light coming from below, and how it is reflected in the brushed aluminium roof extending halfway over the walkway on the dam. The columns in the facade are deep and close together, so one can not look in through the windows until one is standing on the dam itself and looking directly inside. Looking through the windows, one can see the large generator hall, and the four generator tops on the floor below. Across the room and through the opposite windows, one can see the river twelve meters below, continuing south. Walking across the dam, one is invited across the covered bridge, and into an open space under the same roof, to view the canyon carved by the water, and to experience the shift in scale from the low, bright building on the shore of a calm lake, to the giant building rising from the surface of the rushing river.

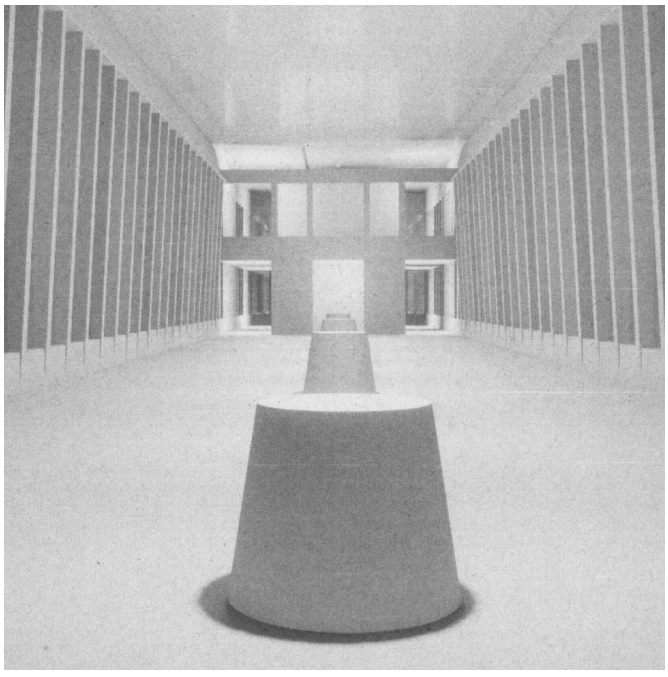


Image from the generator hall

Arriving at the station from the west side

The first hydro stations

When the first hydro stations were developed at the turn of the last century, the question of national self determination was being discussed, triggered by the growing interest by private companies to utilise natural resources at an industrial level. In the case of hydro power, by putting rivers and waterfalls in pipes. Sam Eyde was a pioneer in Norwegian hydro power development, as he founded Norsk Hydro with his science partner Kristian Birkeland, to make artificial fertilizer through creating nitrogen out of thin air using electric arch ovens. The political opposition argued that the future of the country's nature should not be determined by private interests, but through democratic process in parliament. In 1907, the Svælgfos hydro station was built. At the time it was one of the largest in the world, only surpassed by the Ontario Power Company facility at Niagara falls in the US[1]. This massive building in rural Notodden, Norway needed to look beautiful, Eyde thought. It needed to be accepted by the population in the area, and also on a national level. Eyde emphasised beauty in the architecture, and commissioned famous Norwegian painter Theodor Kittelsen to make five artworks of the facility, to show the beauty and potential of this new kind of building. In doing this, Eyde successfully marketed this kind of architecture as something beneficial though invasive, and linked it to a growing national spirit. Kittelsen's paintings places the new time's industrial building in a mythical aesthetic, resulting in a positive attitude towards similar projects in the future.

Theodor Kittelsen, "Svælgfos" (1907)
One of five paintings commisioned by Eyde

Norsk industriarbeidermuseum

Without comparison, Vrangfoss seeks to maintain this attitude. The architecture is sober, but strongly present, it's clear and not overly dramatic, determined to do what it is designed to do, while creating awareness of the consequences of the production of electricity, what it takes to generate the corner stone of everyday life.

1 https://www.statkraft.no/Energikilder/vaare-kraftverk/norge/Svelgfoss/

Looking south through the gap between the station and the cut rock wall below the dam

The people working at Vrangfoss are highly skilled mechanics, engineers and IT-administrators. However, with the generators being more or less automated, and day to day maintenance at one station often isn't required, the workers are spread out over the four power stations, combining their efforts when needed, operating out of the hub at Vamma station. Because of this efficiency, the Vrangfoss station is much smaller than the other three which needed to operate autonomously in their time, with a much larger staff, and sufficient space to take on any unforeseen challenge. There are of course space for maintenance and repairs at Vrangfoss as well, but for bigger jobs, any of the other station's facilities will be used.

In conclusion, the Vrangfoss hydro station sits within an existing natural and technological infrastructure for hydro electric power production, allowing for added output of electricity while lowering the impact on the local flora and fauna compared to developing an untouched site. The architecture of the dam and power house has a strong and clear presence and language, made possible by the existing stations and staff. The building emphasises the changes in scale in nature created by the shaping and facilitation of the landscape, and the changes in the forces of nature through the conversion of potential energy in the dammed up water to the electrical energy fed out through the grid. It is a building that states it's presence and it's demand while not competing with the nature surrounding and supporting it.

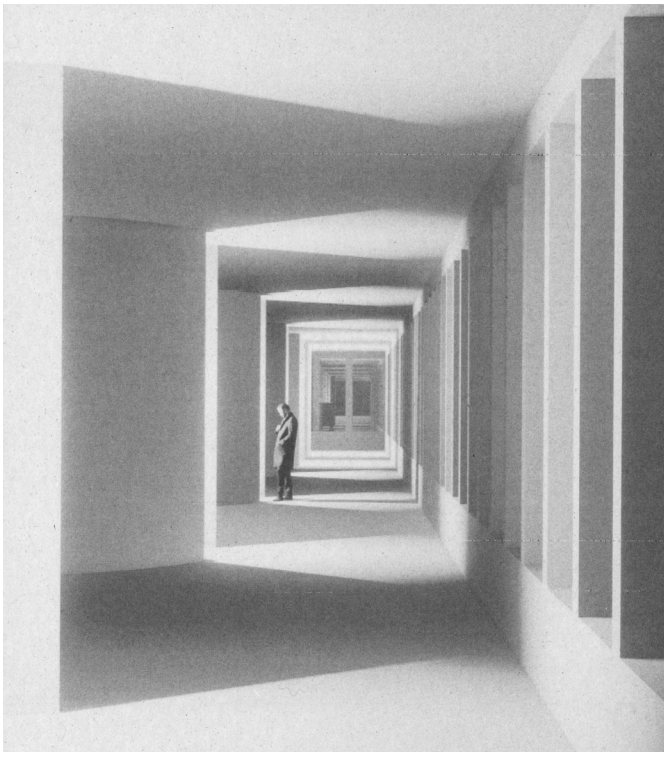


Image of the cores surrounding the spinning shafts extending from the turbine to the generator