

The background of the entire page is a grayscale photograph of a mountainous landscape. The scene is shrouded in mist or low clouds, which partially obscure the forested hillsides. In the middle ground, a single high-voltage power line tower stands prominently against the hazy background. The overall atmosphere is serene and somewhat somber due to the monochromatic palette.

NORWAY'S

HYDROPOWER

POTENTIAL

By Nouska du Saar



A damp cloud flows around a mountain in Rjukan

In Rjukan, the largest upgrade project for hydropower plants in Norwegian history has begun. The renewable energy source accounts for 98 per cent of the total electricity production in Norway and has the unique power to store energy. Experts like to see this potential turn into Europe's 'green battery'.

Damp clouds slide down the fjell, mountains, and cover the middle parts as a blanket. The crystal clear lake reflects the fjell and makes it a typical sight of a Norwegian fjord. Meanwhile the bus meanders on the mountain road in Southern Norway towards Rjukan, northwest of the Notodden in Telemark. The deeper it drives into the nature area, the more waterfalls appear. Stripes of snow decorate the highest peaks before they turn into streams of water. It is May so after a warm winter the melting period has begun and lakes will start to fill up again. So will the reservoirs of more than 740 hydropower plants in Norway, which will provide 5 million Norwegians nearly all the electricity they consume for the upcoming year.

Largest upgrading project

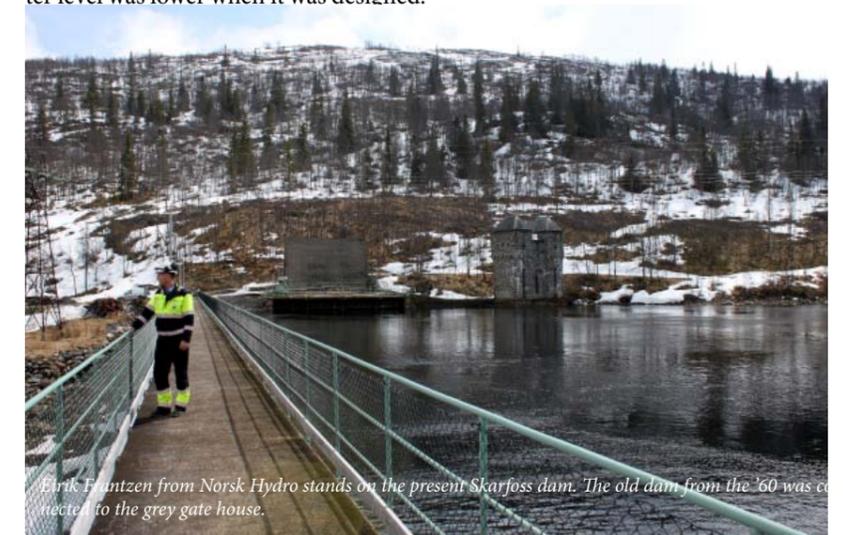
This summer is business as usual, but not for Norsk Hydro, the second-largest producer of hydropower in Norway. It is about to commence the largest upgrading project for hydropower plants in Norway in Rjukan, where five of its seventeen plants reside, good for 30 per cent of the company's annual hydropower production. In tricky jargon, the project costing 800 million NOK (\$141 million) consists of: the rehabilitation of two power units, the exchange of a turbine runner, one generator and the main transformer and necessary maintenance. And the construction of a new dam. During a tour around the house, Eirik Frantzen, Head of Energy projects and Technical support, explains the project which will last until 2014. With the tour comes a bright red work suit and a helmet. Frantzen calls his colleagues at the construction sites before driving there: "To let them know we are coming. They are doing some blasting there, and Hydro's safety goal of zero injuries during work is for a reason." Norsk Hydro accounts for about 8 per cent or 120 TWh (terawatt-hours) of Norway's total power generation. But unlike state-owned and Norway's largest hydropower producer Statkraft,

its electricity is not meant for Norwegian households to warm the heaters. Most of the electricity is used for Hydro's aluminum production. The production per year is hard to tell with hydropower plants. The hydropower output in the Nordic region varies due to the fact that the amount of water available for hydro production shifts from season to season. Frantzen: "Last year for example we had loads of rain and 2010 was extremely dry. But the annual amount of rain is increasing. I can see that after 12 years of working here." More water each year in the reservoir can increase the risk of extreme flooding. "The old stations and dams are not good enough to withstand this increase. That's why the dams are 'recalculated' each 15 years. In 2000, we found out that the same components in different Rjukan sites were outdated. Components can be 50 years old in this area."

Risky dam

Skarfoss is a construction site with such a high risk. The reason for a new dam, meters away from the present one, is the outdated architecture. Frantzen: "This dam is hollow from the inside, it is just two plates on the outside against the water and the high pressure. The new dam will be 100% filled with concrete and can withstand the water pressure. The Skarfoss dam is divided in the group of dams with the highest risks, because if it floods, more than 150 inhabitants will suffer from the consequences. New calculations show that it is actually more than 150. Plus, the regulations from the authority are more strictly now. The Skarfoss dam was originally built like this because the water level was lower when it was designed."

Underneath the water's surface, the previous dam of 1960 is showing its top. Hydro did not tear it off when it built the Skarfoss dam and that comes in handy with the current construction work. The constructors will lower the water level so it reaches the old dam, instead of emptying the entire reservoir. That would destroy the fish's habitat. "There are not many environmental organizations fighting for that anymore. It is not a big issue in Rjukan", says Frantzen. Hydropower does not produce any air emissions, but large dams have environmental issues such as flood control, water quality, and fish and wildlife habitat to deal with. "But there are 'just' two types of fish living here, that lowers the interests. But of course, a reservoir is not an ideal habitat for a fish: the water level changes often. To compensate that, we set out new fish." Another typical hydropower disadvantage is flooding, which is on Hydro's agenda at the moment. The water level at the Møsvatn reservoir, the largest and first one of the five dams that restrains the river, is six meters high. "But it should be completely empty for the projects. There's a 95 per cent chance of the dam flooding this summer, because the water will not run since Hydro does not produce electricity this summer. The plant has a break, for the constructions, so the water here will stand still." Frantzen does not worry about the flood since there are no people living behind the Møsvatn dam. "If there is a flood, we will just let it happen. We build trenches to let the water flow away. It's simply a loss of energy and therefore money."

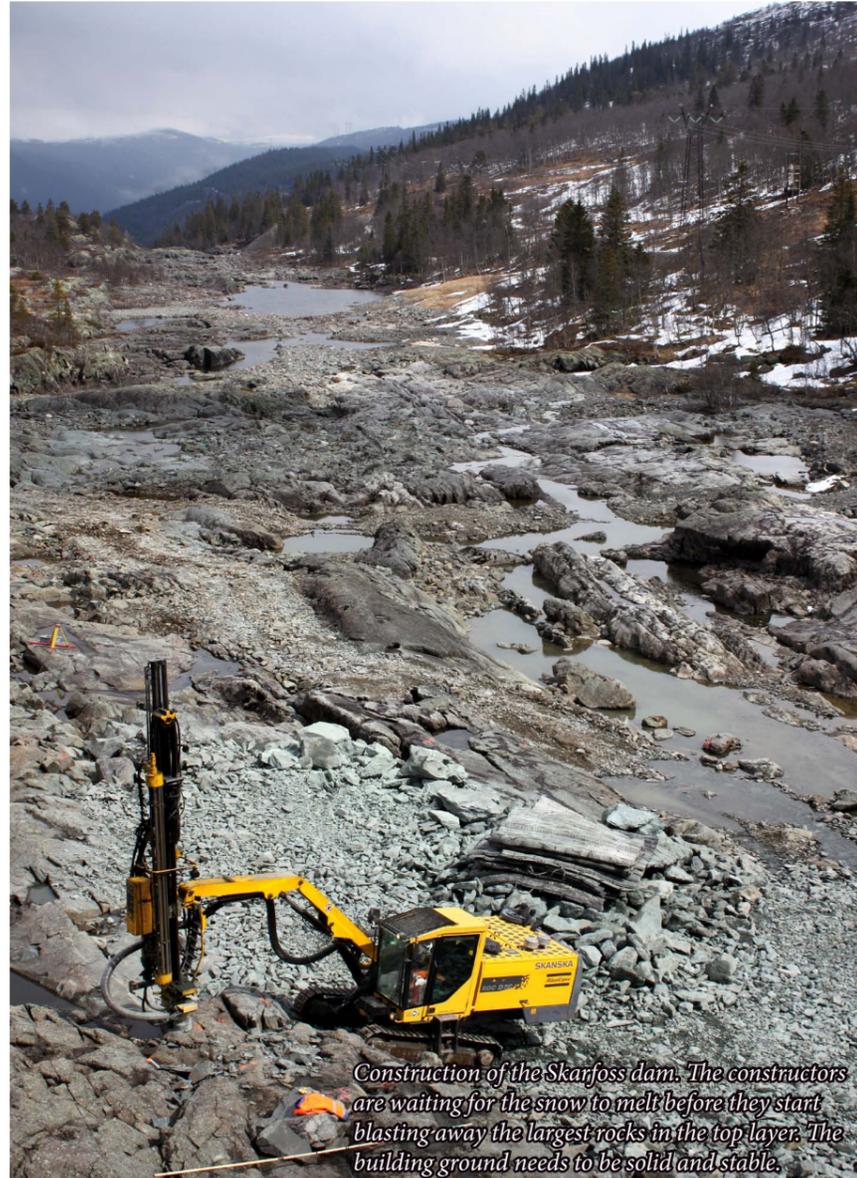


Eirik Frantzen from Norsk Hydro stands on the present Skarfoss dam. The old dam from the '60 was connected to the grey gate house.

Hydropower restrictions

Frantzen and the construction workers will not be able to slappe av, relax during the project. Other updates are cleaning tunnels, upgrading doors and painting an outflow of Vemork. Frantzen: "There is a lot of work to do in a short time." Vemork was constructed by Hydro in 1911 and was the first plant in Southern Norway. It is out of use since 1971, and instead accommodates the Industrial Museum. "We build a new plant inside the mountain. The outer pipelines were starting to leak and we are not allowed to use them. The Norwegian government decided the plant has historical value." The government has a lot to say about hydropower. For example, Hydro is not allowed to build any large plants.

"We have opened two new plants in April and July this year. But we do not plan for large plants. The biggest areas in Norway are already used." According to the Ministry of Petroleum and Energy, in 2009 Norway had developed 122.7 TWh of its potential 205.7 TWh annual hydropower generation. Plus, the government wants to save waterfalls for tourism. 22 per cent (45.7 TWh) of the potential 205.7 TWh is protected. Frantzen: "I think it is good to have something left because Norway's nature is special. And the tourists still come to see our mountains and waterfalls. But we like to exploit the areas where grids and cables already exists. So we focus on the Sogn area for small and medium plants." The Rjukan area seems exploited thoroughly, when Frantzen walks into the long tunnel behind the Vemork museum leading to the station deep inside the mountain.

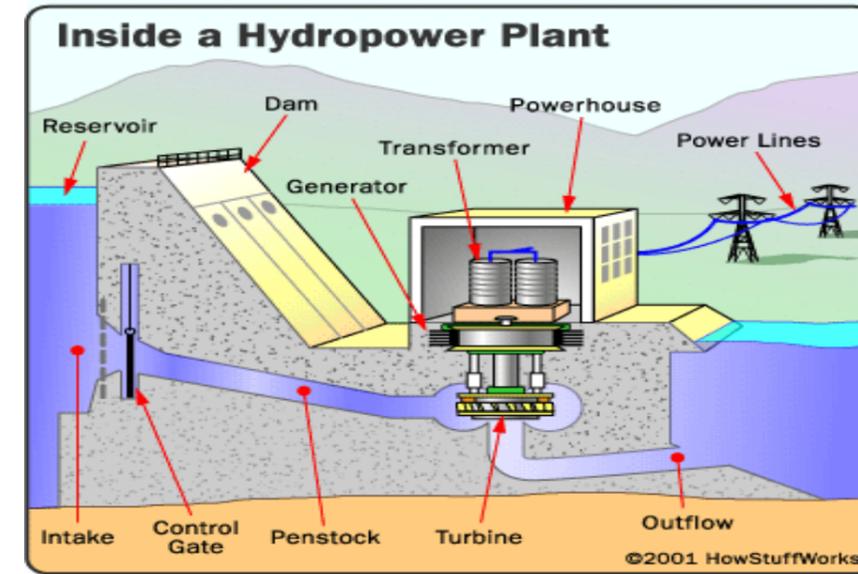


Construction of the Skarfoss dam. The constructors are waiting for the snow to melt before they start blasting away the largest rocks in the top layer. The building ground needs to be solid and stable.

Constructors are drilling new tunnels inside. "It is important that we empty the waterways before the real construction begins. If there is a high water pressure inside, the tunnels can breach. Therefore we make holes to measure the pressure of the ground water level." Helmets on, then. We carry a flashlight, 'just in case the light gets cut off'.

Power to store energy

In the last 20 years, Hydro connected its energy to the international electricity grid. Norway is part of the Nord Pool Spot, the Nordic power exchange grid. Half of its annual power generation of 400 TWh is derived from hydropower, which also is the cheapest source according to Nord Pool Spot. In dry years, the Nordic countries grow more dependent on energy import from other countries: Russia, Estonia, the Netherlands and Germany. For example, between the north of the Netherlands and Southern Norway lies the NorNed High Voltage Direct Current link, the world's longest power cable of 576 km long. It connects since 2008 the Norwegian hydropower-based production system with the Dutch heat-based (mostly gas) production system. Norwegians use most electricity to heat their houses during winter and nighttime, when the use of electricity in the Netherlands decreases. So during nighttime, Norway receives power from the Dutch production system so it can pump water back to a higher reservoir. That ability to pump water back up and reuse it the next day, is the core of the European discussion about Norway's pumped hydropower storage. Olav Hohmeyer, professor of energy and nature reservation at the Univeritetet i Flensburg, believes the future of Europe can be saved with Norway's possibility to store the hydropower. In an interview with Teknisk Ukeblad in October last year, he says: "It is reliable because the plants can store energy and release it when they wish." When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. This pumping relatively costs a minimum of the produced electricity. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.



It is the possibility to 'store energy' in this way, that makes this renewable source unique next to wind and solar power. Norway has around 40 to 50 per cent of Europe's total reservoir capacity, and according to the Norwegian Water Resources and Energy Directorate (NVE) the reservoir capacity is 82 TWh, of which 34 TWh is located in the south of Norway.

Green battery

Professor Hohmeyer researched if it was possible to supply Tyskland, Europe and Northern Africa in 100 per cent sustainable energy sources, and it was. He presented a report about it to the German Parliament, suggesting Germany could be provided completely by renewable energy by 2050. With an important role to play for Norway. But it depends if Norway wants to become a 'green battery' for Europe. The expression 'green battery' is buzzing around among professors, politicians and energy companies. The buzz is not yet as loud as the noise the hydropower turbine and generator produce at the Vemork plant. Norsk Hydro does show interest in the concept, although it has its setbacks. Franzen: "With the battery idea, we have to produce electricity when the demand, also from other countries, is high. Meaning more electricity in a shorter time. Hydropower plants supply a stable amount of energy over one year's time. If Norway becomes a battery, the plants have to satisfy the demands and stop at night for example. This would make the price fluctuate."

That is exactly one of Ola Borten Moe, Minister of Petroleum and Energy, his arguments against the green battery concept. Responding to professor Hohmeyer statement in Teknisk Ukeblad, he said: "I do not believe Europe can balance its power with Norwegian hydropower (...). This type of expansion comes with enormous investments in the cables and electricity masts." And not to forget, the constructing of more hydropower reservoirs to store and release water. Borten Moe added to this: "Gas does have the possibility to regulate power and function as a back-up." It is no secret that the oil and gas sector is dominant in Norway.

Hydro's plants in Rjukan are based on rivers and melting snow. A steep mountain provides a hard inflow of water. In the bottom of a reservoir, an intake or tunnel leads water to a hydropower station build inside a nearby mountain. The water builds up a lot of pressure along the way and strikes the blades of a turbine, which is attached to a generator above. Magnets in the generator turn equally with the turbine blades, producing 'alternating currents' or moving electrons. The transformer above converts the current into higher-voltage current that finally reaches the power lines. Used water flows out, back into the river.

According to the Ministry of Petroleum and Energy, in 2010 the gas exports were about nine times that of the electricity production. Norway is the fifth largest oil exporter and the third largest gas exporter. It also is no secret that Minister Borten Moe encourages oil activities, for he announced last summer that new areas will be opened up for oil and gas exploration. But in February this year the Minister withdrew his opinion: "I will also continue to promote even more use of renewable energy in Norway. Over the next decade we are committed to an unprecedented effort to further increase our share of renewable energy." From the fact that Ola Borten Moe moderated his opinion, it can be assumed that he does allow overseas interconnections.



'Behind the Vemork museum a tunnel appears, which leads to the plant built inside the mountain. Helmets on, then. We carry a flashlight, 'just in case the light gets cut off'.

Stakeholders decide

That would be good news for Norsk Hydro, which is connected to the international electricity grid. “We have projects researching the possibilities in the context of the green battery for a big reservoir in Røldal, in the west coast of Norway. But Norway needs more electricity cables on the grid to handle the huge energy supply if it becomes a battery.” And that causes controversy, both politically and publically. Norwegians are attached to their nature and think of electricity masts as scars running through the fjords. “I don’t see Norway become the green battery before 2020. It is impossible to build more cables in such a short time.” But the green battery concept needs more support in any case. Many Norwegian stakeholders are at play for this matter, and they are all interested in economics. However, the Smart Energy for Europe Platform (SEFEP) writes in its report that ‘experts worry that if Norway hesitates too long to take up the role as Europe’s green battery, Europe will find another way to reach its renewable energy goals.’

Eventually we will all have to cope with rising electricity demands. According to the U.S. Energy Information Administration, today the maximum power consumed worldwide is about 12.5 terawatts. The agency reports that in 2030, we will demand 16.9 terawatts as global population and living standards rise.

During the travel back from Rjukan to the inhabited world and Norway’s capital, I suddenly notice the electric power masts everywhere. As monster masts they pierce through the mist on top of the fjell. Their cables lead to companies where the hydroelectricity is consumed, no matter what season. And to households, where at night all the street lanterns remain turned on, and all the electric heaters remain burning.



Tiny stalactites, produced from the river’s calcium, or chalk, can be spotted around the turbine and transitions.



Vemork’s machine hall with two actual plants. Two transformers, generators and turbines are situated several floors down.



Eirik Frantzen shows how Hydro’s employees use simple cards to know who’s attending inside the plant in case of emergencies.

SEFEP. (January 2012). ‘Norway and the North Sea Grid’, SEFEP working paper. www.sefep.eu



Vemork now houses a museum, and inside the mountain a station. Hydro’s four other stations in Rjukan are Sâheim (known for its stunning architecture), Froystul, Moflât and Mæl

