PUMPED ENERGY STORAGE

©M. Ragheb
5/25/2012

INTRODUCTION

Ice cores from Greenland and the Antarctic prove that the CO_2 concentration in the atmosphere in the last 800,000 years has fluctuated between 180 and 280 ppm But current readings at Zeppelin Mountain in Norway read 400 ppm. In winter, the CO_2 levels are usually higher because fewer plants are growing. In summer the values sink again. But the annual back and forth has long been out of sync. And the amount of greenhouse gases in the atmosphere is growing at a faster rate. A couple of years ago, there was a rise of one ppm per year, and the current level is 3 ppm per year.

Pumped storage hydroelectric power plants are considered as the most efficient energy storage alternative. The technology has been in use for 80 years at the Schluchsee, a reservoir in Germany's southern Black Forest region.

Up to 6,472 gallons or 24,500 liters of water flow down through a pressure shaft every second, coming from the Eggberg reservoir, which is about 400 meters above the Schluchsee.

The mode can be switched within only 90 seconds, so that hydroelectric power production can be stopped and water is pumped back up to the upper basin. No other system can be adjusted as quickly to whether electrical energy needs to be delivered to the grid, or has to be stored at any given time. In comparison, a coal power plant takes 12 hours to warm up to full capacity. This flexibility makes a pumped storage hydroelectric power plant quite valuable.

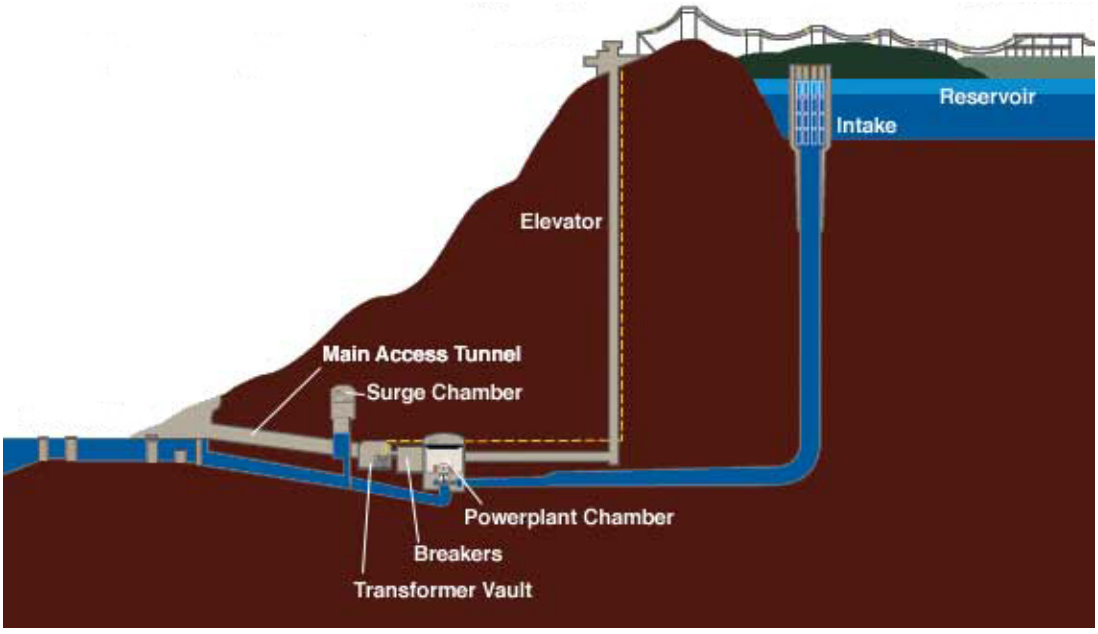

Figure 1. Pumped Storage system configuration.

At the Schluchsee, the growing supply of wind energy benefits the plant. The water turbines are currently being switched between operating modes 60,000 times a year.

Another power plant is planned in the region, in the town of Atdorf. At a site where a hiking path now passes along a ridge, a reservoir will be dug and a tunnel will be excavated through gneiss and granite rocks, 600 meters down to a second reservoir on the Rhine River plain. About 272 acres or 110 hectares of land will have to be dedicated to the pumped storage hydroelectric power plant.

A Dutch engineer, L. Lievense proposed the linking of 1,000 wind turbines of 3 MW of rated power each to pump water into a 165 km^2 water basin. The wind turbines would pump the water to a higher level than the surrounding Ijsselmeer into the basin. The water would be later allowed to drive water turbines at peak electrical demand or at the times where there are no productive winds.

Figure 2. Eggberg reservoir supplies water to the Schluchsee power plant. Schluchseewerk AG Photo.

Figure 3. Schluchsee pumped storage hydroelectric power plant. Schluchseewerk AG Photo.

Germany has storage plants with a capacity of 6,400 MWs and is capable of expanding that by 2,500 MW. However, it needs 10 times more than that in new energy sources: 25,000 MW.

Figure 4. Pumped storage plant at Wendefurth, Central Germany. Source: DPA.

Figure 5. Kvildall hydroelectric station, Norway.

PUMPED STORAGE IN EUROPE

Norway in general, and its Statkraft power company in particular, generate power almost completely from hydroelectric power plants, without appreciable CO2 emissions. Germany and other European countries should, with the help of these facilities, make their own energy production more environmentally-friendly.

The aim is to make the chronically inconsistent energy producers like wind and solar energy more reliable. The Statkraft chief wants nothing less than to make Norway's hydroelectric power plants the rechargeable battery of Europe. That is technically possible, because the facilities are to a large extent pumped-storage hydroelectric power plants, which create a buffer. With excess energy, for example from Germany, water is pumped from below to the higher level.

Figure 6. Turbine hall of Waldeck I station, Germany.

Spikes in electricity on especially windy or sunny days that otherwise would destabilize the German network could be thereby logically be used. The pump turbines only need about three minutes to go from a standstill to full power. An energy shortage in the south would send the water flowing back into the lower reservoir, up to the point where there is a 1,000-meter height difference.

Generators then produce electricity that could flow back to Germany. "That is one of the most efficient ways to store energy. Even though about 20 percent of the electricity is lost during these trips back and forth, alternative buffer technologies like hydrogen or natural gas production from wind energy or compressed air reservoirs are less attractive.

Germany will have problems keeping its electrical grid stable after the remaining nuclear power plants and old coal and gas powered plants that currently offset imbalances are no longer operational. With 200 to 300 additional installations, Norway could store 25,000 megawatts from Germany and other European countries in its reservoirs on short notice. That would be one-third of the average power used on the German grid.

ENVIRONMENTAL EFFECTE

Such a plan would require numerous new overhead power lines. The network in southern Norway is currently not yet ready for a connection to a North Sea electric highway. New poles disturb residents, and there have already been protests on the Hardangerfjord. In Germany, too, it would require new electricity lines, an equally difficult venture.

For the bold vision to become a reality, there would also need to be connections over the North Sea. Rynning-Tønnesen says about a dozen would be needed in order to realize his ambitious 25,000-megawatt plan. German energy companies estimate the number to be even higher. And only one cable is currently being worked on.

SEABED CABLE TRANSMISSION

The €1.4-billion project "NorGer," the Norwegian company Statnett is planning an almost 600-kilometer-long high-voltage power line on the seabed. The HVDC direct current cable should, starting in 2018, transport 1,400 megawatts between Norway's southern coast and the Netherlands.

Many uncertainties remain. It will be disputed where exactly in the North Sea underground cables will be connected to the German high voltage grid. The station must convert the direct current from the cable into alternating current that can be used on land. Under discussion is a newly constructed facility near the community of Moorriem in northern Germany and a location at the site of the off-line nuclear power plant Unterweser, on the German North Sea coast.

FINANCING ISSUES

It also remains unclear who will pay for the cables. At Statkraft, they are not ruling out the possibilities of requiring participants to take part in a consortium or buy certain quantities of transmission capacity. Regulatory reasons would prohibit them from building the cables themselves.

Other European countries are also interested in Norway's energy. The Netherlands has had a connection to the Norwegian grid since 2008, thanks to the cable "NorNed." The Danes are connected to their northern neighbors with several cables ("Cross-Skagerrak"). England ("HVDC Norway-Great Britain"), Scotland ("NorthConnect") and recently even Iceland are thinking about cable projects. The British and Dutch and also connected with the newly operational "BritNed" cable.

REFERENCES

1. Christoph Seidler, “Renewable Energy Ambitions. Norway wants to Become Europe’s Battery,” Der Spiegel, May 24, 2012.