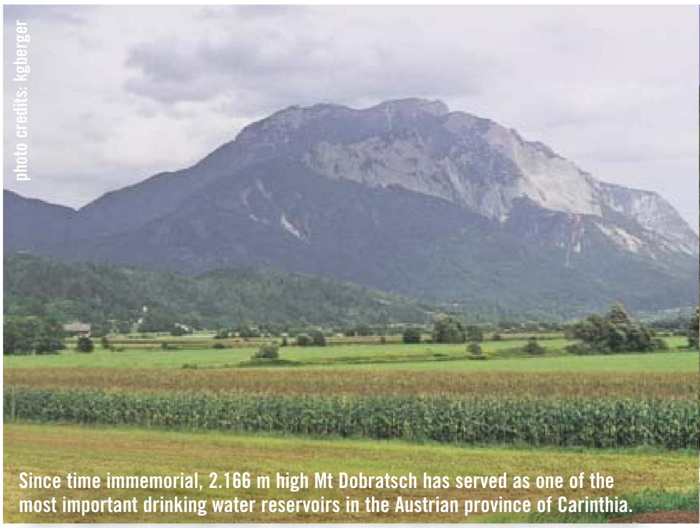
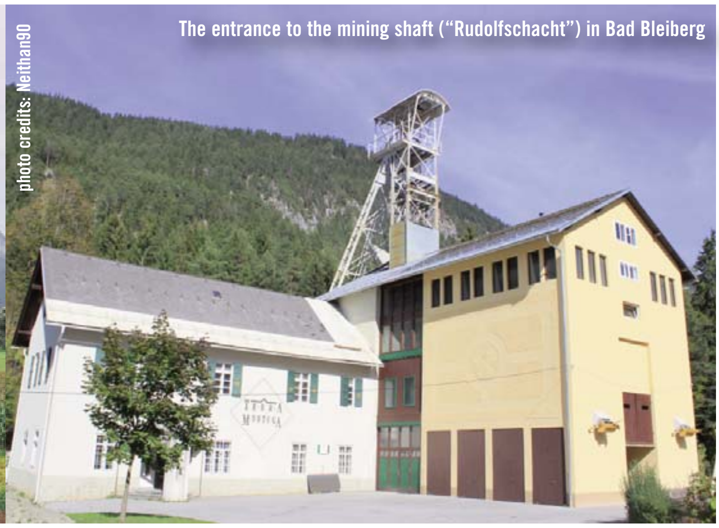


Since time immemorial, 2.166 m high Mt Dobratsch has served as one of the most important drinking water reservoirs in the Austrian province of Carinthia.



The entrance to the mining shaft ("Rudolfschacht") in Bad Bleiberg

AUSTRIA'S FIRST MINE-MOUTH POWER PLANT IS MINING ECO-POWER

In the tradition-steeped Carinthian mining town of Bad Bleiberg there is a whiff of renaissance in the air. Not that the zinc and lead mining operations of yesteryear has been revived. But in view of the recent construction of Austria's first mine-mouth power plant at 250 m below ground it would be no exaggeration to speak of a highly innovative re-use of closed-down mining cavities. Getting this small-scale power station built was no small feat. In addition to complex negotiations with the authorities it also required a series of special technical solutions. But in the end the efforts of project operator AAE Entwicklungs GmbH were crowned with success. The Bad Bleiberg hydropower station has been a reliable source of eco-power for about a year now, generating around 1.5 million kWh per normal year.

High up in the mountain valley between Mounts Dobratsch and Erzberg in the Bleiberg region of Carinthia, the ground looks perforated like Swiss cheese. During the region's mining history, which goes back more than 800 years, the miners have constructed an elaborate system of 1,300 shafts and tunnels with a total length of 1,200 km. Especially lead and zinc have been mined here since the second quarter of the fourteenth century. Back then, the mining industry was the economic backbone of the entire region. By the end of the eighteenth century, Bad Bleiberg had 4,000 inhabitants – a quarter more than today.

The first sharp decline for mining came during the time of the big world economic crisis. In 1931 all mining activities were suspended for a whole year. But the most significant turning point in local mining history happened 20 years later, when excavation work at the twelfth run caused water to flood the tunnels at a rate of around 3,000 litres per second. The tunnel system was completely flooded up to the eighth run. It was a catastrophic situation, which the miners tried to remedy by means of the most advanced pumping technology available at the time. In the end, they actually succeeded in getting the water out of the tunnels. But this was when something extraordinary happened: the water turned out to be 28 °C warm thermal water. Along with the water, the basis for today's spa and wellness tourism had emerged, eventually turning the catastrophe into a blessing.

DRAINAGE INTO THE DRAU VALLEY

The miners had almost reached sea level in their excavations into the depth. The "Rudolf Blindschacht" (underground tunnel), which was named after Austrian Crown Prince Rudolf, reached down 850 m to only 87 m above the Adriatic sea level.

All water streams converge in a distribution system in the building of the Rudolfschacht.

One of the most important tunnels – the "Kaiser Franz-Josef-Stollen", took eighteen years to excavate: from 1894 until 1912. With a length of 12.8 km, it provides the essential connection between the Antoni shaft and the Drau valley. It was through this tunnel that the miners were able to drain all trapped water and most of the pumped water into the River Drau. This water was then used by the Töplitsch hydropower station to generate electricity.

However, electricity was also generated inside the mine itself. A power station had been erected at the fifth run, around 250 m below ground. From 1918 onwards it provided the electricity needed to power the underground mining equipment.

WATER DOWN THE DOBRATSCH

All through the mining history of Bad Bleiberg, water has played a key role in local mining operations. One essential contributor to the water supply was nearby Mount Dobratsch, a 2,166 m mountain composed primarily of porous limestone, which has served as a source of drinking water for centuries. One of the mountain springs is the

Nötschbach spring, which emanates at 1,015 m above sea level and delivers up to 500 litres per second when the water levels are high.
This water used to be pressed towards the reverse slope to carry the water off via the Antoni Shaft towards the Drau Valley, but also to lead it into the Muskari reservoir. This reservoir has a capacity of 3,000 cubic metres and used to serve as a level sensor for the old small-scale hydropower station at the fifth run.
The mining level is exactly the one that is still located just above the flooded tunnel system today. When the mining operation was shut down in 1993, more and more water kept seeping into the mine, eventually flooding the system up to the fifth run at around 250 m below ground level. Immediately beneath it, the water is carried towards the Drau Valley by way of the drainage tunnel.

HOBAS GRP (glass-fibre reinforced plastic) pipes in the building of the Rudolfschacht (top left). Installing the GRP pipework (bottom left) The bend of the GRP pipes was achieved through the use of angulated pipe sockets (centre). Right: A century-old grey cast iron pipe, which was manufactured in England in 1890. The socket consists of a layer of small wood panels (top).

TOUGH NEGOTIATIONS FOR PERMISSION

Credit for the idea of constructing a small-scale power station at the age-old mining site is due to Dipl. Ing. (Master of Engineering) Christoph Aste, who was the first to become aware of the site's potential. Since 2004 he has been pursuing the project with great patience and persistence, clearing all the many administrative hurdles to finally obtain building permission. "Being able to re-use the shut-down mining areas in this case required a mining permission in addition to the usual water usage and electricity generating permits and licenses. That led to a whole series of problems: after all, the electrical norms and regulations under ground are completely different from the ones that apply above ground. It took us years to get all three permissions sorted out. In the end, it was the mining authorities who broke the ice, by granting a permit in accordance with the legal requirements for above-ground operations. They justified their decision by saying that in the case of shut-down mining sites like this it is not necessary to apply the regular mining regulations," says Christoph Aste, who was finally handed the overall permission to go ahead with the hydropower project in 2009. Together with AAE Wasserkraft GmbH of Kötschach-Mauthen (Carinthia), the project stakeholders founded AAE Entwicklungs GmbH, which was to complete the hydropower plant within around 16 months.

USING DIFFERENT WATER SOURCES

Christoph Aste's ingenious concept not only called for the use of water from the Nötschbach spring, which may be used up to a volume of 100 litres per second, as per an age-old permission granted back in the old days of the mining operation. In addition to this water source, Aste's plan included the use of water from the Muskari reservoir and all other mountain water sources that can be viably collected and led to the power station. A distribution system was to be installed at the entrance of the Rudolfschacht, which was to carry the water from all incoming sources to the penstock. The penstock itself was to lead straight down along the outer wall of the Rudolfschacht to the site of the old power station at the fifth run. The machine unit was to be installed at a depth of 250 m below ground level. This was not only to generate electricity, but had to be able to withstand the adverse conditions under ground for decades to come.
The energy is carried away from the mountain on the low-voltage side. "Of course we could avoid conduction loss by increasing the high-voltage power," explains Aste. "But we decided against this, for security reasons. After all, one has to consider that there is always the danger of water leakage. In the end, it would just be too dangerous."

Visit to the machine cavern 250 m below ground level: Michael Bader (EFG), DI Christoph Aste (Project Developer, Planner and Plant Co-Operator), and Werner Goldberger (EFG Managing Director) (from left)

ANCIENT PIPEWORK MEETS MODERN REPLACEMENT

One of the first tasks in the project concerned the penstock from the Nötschbachquelle. The existing one was the original pipe that was laid in the 1890s. "The old DN360 penstock pipes made from English grey cast iron were quite extraordinary. Although their walls were only a little more than two and a half centimetres thick they were extremely solid and still in excellent condition. The pipe sockets are covered with small, chip-like larch wood panels, which swell up as they soak up the water. This way, they keep the connection tight as long as they remain soaked with water. We put the pipes to the test, and they

EFG Project Manager Gero Pretis can look back in satisfaction on a successfully completed project.

proved to be literally airtight. So we left the old penstock in place down to the first low point," says Aster. From this point onward, however, the engineers relied on the qualities of modern pipework engineering technology. A little downstream of the stream capture, near the culvert, the old pipes were cut off and replaced with GRP pipework (DN300, SN10.000, Pressure Rating PN16) by HOBAS.
The pipe now covers the 980 m distance to the shaft building on the other side of the valley. Says Aste, "The HOBAS pipes allowed us to design a solution that is both highly functional and cost-efficient at the same time. Best of all, we hardly had to use any pre-shaped pieces. This is because we were able to achieve the necessary bends with angulated pipe sockets and cut-off pieces, which were pre-fabricated at the HOBAS production facilities. The people at HOBAS really helped us a great deal with that during the planning stage."

CERTIFIED MINING STAFF INSTALLS PENSTOCK

In the shaft structures of the Rudolfschacht the transitional link to a cast iron pipe was installed in the form of a steel socket. From there, it leads off into an elbow and on to the penstock, which was made from ductile cast iron pipes by Duktus. The vertical installations were implemented using DN250 calibre pipes with a cement-mortar lining. "Using a larger dimension was simply out of the question, as we were already pushing the space limits," says Aste, commenting on one of several difficulties the engineers encountered during the installation of the penstock. "Only authorised, certified mining personnel is allowed to perform installation work in the shafts. And even they kept running into all sorts of difficulties. The danger of falling rocks limits the ability for miners to work on different levels above each other, which also limits the size of the working teams to only a few people. Also, installation was only allowed at night to avoid disturbing the spa guests in the nearby treatment tunnel at the first run." Installation began at the bottom and proceeded upwards. The pipes were fastened into place by means of specially developed clamps and anchored to the walls of the Rudolfschacht with dowels. Although 20 cm dowels were sufficient for the deeper limestone layers, the layers closer to the top required the use of 2-metre anchors to fasten the penstock into place. "What really surprised us was that the shaft was not quite level, according to our measurements. This meant that the installation team had to expand the shaft with a jackhammer at one point," as Christoph Aste recalls.

WORKING UNDER EXTREME CONDITIONS

Downhole work was generally hampered by a series of problems that power plant construction engineers would never encounter under normal conditions. Werner Goldberger, Managing Director of EDF of Feldkirchen, which supplied the electromechanical equipment, can tell a thing or two about it: "You had to climb around twelve hundred steps to get to the machine cavern. If you forgot something up there you just had to do without it. Even our most athletic colleagues were barely able to get there and back again more than once a day. As if that was not enough, communication was extremely difficult as well. It should have been possible to talk to colleagues in the machine cavern by walkie-talkie, but in practice the connection was anything but optimal. Working in a confined space in artificial light and extreme humidity 250 m below ground level took a lot out of our people. Their notebook computer stopped working after about half an hour. The conditions down there are really tough, especially considering that there is always the danger of the light failing. You have to keep your calm under any circumstances. Looking back, I can only say that it takes really well trained staff to do this kind of job – people who are used to coping with conditions like these."

MACHINES, 'TROPICAL STYLE'

The entire project was technically extremely demanding on everyone involved. Especially the core element of the facility, the turbine-and-generator unit, had to be designed specifically to withstand the extreme conditions under ground. As EFG's project leader Gero Pretis explains, "Due to the high humidity levels – around 90 per cent – the entire turbine had to be made from stainless steel. For the same reason, the generator by Hitzinger was delivered with an additional insulation for tropical climate conditions. It's the only way to ensure reliable operation for decades to come."
As one might expect by now, transporting the machine unit to its destination turned out to be a difficult, extremely sensitive undertaking as well. Both the turbine and generator had to be hauled downwards by means of a cable winch. Especially moving the generator along its gui-

Technical characteristics

- Flow Rate: 120 l/s
- Net Head: 322 m
- Turbine: Pelton Turbine
- Nozzles quantity: 2
- Manufacturer: EFG
- Turbine Capacity: 341 kW
- Rotation speed: 1'500 rpm
- Generator: Synchronous Generator
- Manufacturer: Hitzinger
- Average Energy Capacity: 1.5 GWh

Project Developer Dipl. Ing. Christoph Aste and Michael Bader (EFG) performing the monthly inspection of the machine unit.

ding tracks did not work out as expected, but the efforts were finally crowned with success. Once delivered safely to the bottom of the pit, the generator had to be transported around a hundred metres through the knee-deep water of the Franz-Josef-Stollen to the machine cavern. To protect the machine against the water, it was hauled onto a watertight transport tub, which in turn was placed onto an old mining tram. Packed onto the old transport vehicle, the generator finally made its way through the water into the dry machine cavern.
“All in all, it’s fair to say that as far as workflow is concerned we have entered a lot of new territory. Fortunately, there were no real accidents, and nobody was hurt,” says Aste.

1.5 GWH IN A NORMAL YEAR

Having started work in May 2010, the project team was able to complete their power plant project by September 2011. Today, after more than a year in operation, the facility has proven itself to live up fully to everyone’s expectations. In a normal year, the power station, which is officially known as “Kraftwerk Nötschbachquelle-Rudolfschacht”, will feed around 1.5 million kWh into the grid of electricity provider KELAG. The twin-jet Pelton turbine by EFG is designed for a capacity of 341 kW at a net head of 326 m and a flow capacity of 120 l/sec. The “made in Carinthia” turbine will drive a brushless Hitzinger synchronous generator at a nominal rotational speed of 1,500 rpm.

DOUBLE USE FOR THERMAL WATER

Among the other hydropower plants operated by AAE, the new Nötschbach plant stands out not just for its 1.5 million kWh generating capacity. It special qualities lie rather in the fact that it can provide buffered energy to cover peaks within the grid, thus contributing to an evenly sustained supply of electricity.

To boost these particular qualities even further, project developer Christoph Aste has plans for a further extension of the water utilisation concept at hand: he intends to utilise the thermal water as well – and do so in two ways. At a pressure of 17 bar the thermal water is pumped upwards to the fifth run. “Since the water has a temperature of 28 degrees, we intend to move it all the way up to use its thermal capacity for long-distance heating purposes. The used water will then be fed back into the penstock. This allows us to kill two birds with one stone: we’ll be able to use the water for heating via a heat pump while increasing the annual output of our plant,” says Aste.

PROTOTYPE WITH IMITATION POTENTIAL

Installing power plants in mountain caverns is not a new concept any more. In fact, there seems to be a certain trend towards this type of installation. However, installing a power station inside a closed-down mine is something that has never been done before in Austria. In this sense, the Nötschbach power station serves as a prototype for a hydropower engineering concept that might set a trend for further projects in the future.
Says Christoph Aste, “There are lots of closed-down mines here in the Alps that could be developed into hydropower sites based on a similar concept. One mustn’t forget, many of the issues that can be a real headache for power plant engineers – things such as ecologic concerns, residual water volumes, the interests of local residents, noise and so on – are all irrelevant underground. Of course, we will pass on the know-how that we have gained here to others. However, what would be needed now is a comprehensive potential analysis of these type of projects.”