

Grimsel 2, Switzerland

The world's largest power converter for variable speed pumped hydropower



Upper lake of the pumped storage power plant Grimsel 2 in Switzerland

The world's largest frequency converter for the pumped storage power plant Grimsel 2 in Switzerland was supplied and commissioned by ABB.

The 100 megavolt ampere (MVA) variable speed converter, fitted to the existing generator/motor set, now enables pumping with variable power and results in higher operating profitability. The installation, built on ABB's PCS 8000 converter, sets a new benchmark in flexibility and efficiency of the hydro pumped storage power plant operation.

Oberhasli Hydroelectric Company

Kraftwerke Oberhasli AG (KWO), one of the leading hydroelectric companies in Switzerland, operates 26 units in nine power plants with eight storage lakes spread over the Grimsel and Susten regions in the Swiss Alps. KWO provides on average about 2,350 gigawatt hours (GWh) of electricity per year, the equivalent annual consumption of around 1.2 million people.

The pumped storage power plant Grimsel 2 is equipped with four 100 MVA synchronous units. Each unit has a separate Francis turbine and pump on the same shaft to either generate electricity or pump water.

Challenge

As more and more intermittent wind and solar power generation capacity is added to the electricity grid, energy storage solutions are gaining in importance.

Pumped storage power plants, such as those found in the Swiss Alps, are ideal partners for the expanding use of solar and wind energy. Storage plants provide load balancing to the network, ensuring the necessary parity between production and consumption. Therefore, when power is plentiful, water is pumped from a lower lake to replenish a higher reservoir, where it can remain stored for a long time. When power is needed, water is released, instantly turning turbines as the water falls to rapidly generate electricity.

At Grimsel 2 until now, the only way to adjust the amount of absorbed power during pump operation was to regulate the number of pumps employed. Each pump was only able to operate at full power. Adjustment to the desired power was facilitated by simultaneous generation with other units, thereby consuming valuable stored water from other lakes and generating unnecessary power losses.

In 2010, KWO aimed to upgrade one out of the four units at Grimsel 2 for variable speed operation. Their main target was to increase the operational efficiency by improving the use of the stored water, mainly by gaining the possibility to provide energy balancing during pumping mode.

The challenge was to install a full power converter system for variable speed operation, keeping the electrical machine from the 1980s unchanged. The solution had to be fitted into the existing powerhouse.



One 90 MW machine group comprising generator/motor, Francis turbine, and pump.

Solution

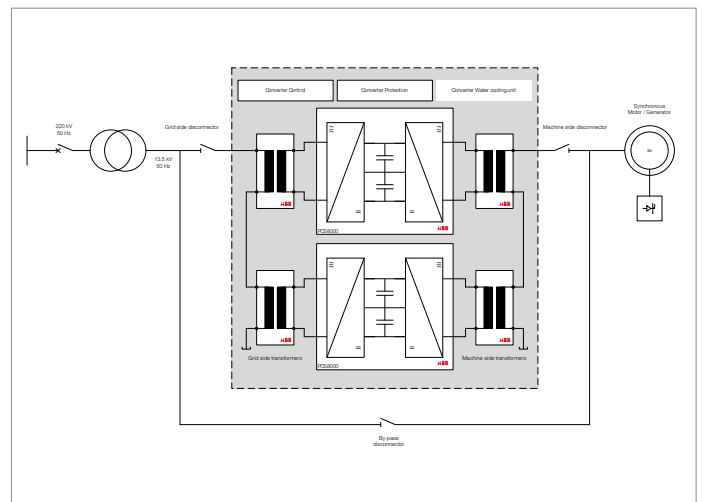
ABB has therefore installed a 100 MVA frequency converter, the world's largest of this kind for a variable speed pumped hydropower application.

ABB's system consists of a PCS 8000 frequency converter, with an AC 800PEC control unit and step-up/down transformers on the converter grid and machine sides. ABB provided system and control engineering, installation, and commissioning of the frequency converter.

A smart converter system design enables a drastic improvement in the voltage quality on the stator windings, ensuring smooth operation with the existing unit without excessive stress on the stator windings.

By means of the full power converter, the frequency on the machine side can be varied, and hence the rotational speed – and in turn the power absorbed by the pump. The synchronous machine now operates between 600 and 765 rpm in pump mode, providing up to a maximum of 94 megawatts (MW) of absorbed power.

For certain operations, the converter system can be bypassed and run in its original mode at fixed speed.



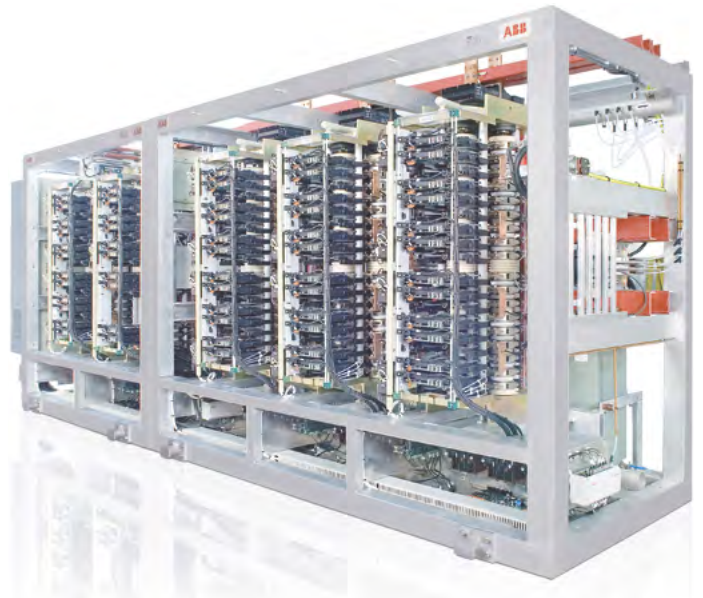
Converter Fed Synchronous Machine (CFSM) - ABB Solution at Grimsel 2

Benefits

The concept of running the synchronous motor/generator at variable speed by feeding its stator with a variable frequency overcomes the limitations of the previous fixed-speed design, providing valuable operational benefits.

- 1 Optimized use of excessive energy on the grid: continuously adjustable energy consumption is provided in pump operation, increasing the amount of stored water.
- 2 Quick start of the pump without water loss: the unit in pump mode is now started by means of the converter within 60 seconds, thereby saving large amounts of valuable stored water.
- 3 Reactive power compensation: the power converter can be operated without the machine as a reactive power compensation system, offering up to 100 MVAR instantaneous support to the grid.

Because it was not necessary to modify the existing generator and step-up transformer, the installation of the frequency conversion unit was possible without impact on the plant's operation, and its hookup caused minimum interruption of service.



Key data: PCS 8000 frequency converter at Grimsel 2

Rated power	100 MVA
Input voltage, current	13.5 kV, 4650 A, 50 Hz
Output voltage, current for pump operation	10.8 - 13.5 kV, 4650 A, 40 - 51 Hz
Output voltage for start-up	0 - 13.5 kV, 0 - 51 Hz



PCS 8000 cooling system



Transformer

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