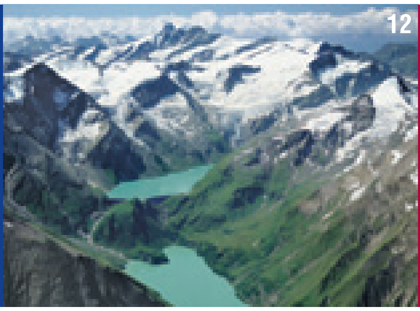
HyPower

Voith Siemens Hydro Power Generation customer magazine

Champions: Peak energy from pumped storage I New aerating technology for Osage I Hydro and Greenhouse Gases

14

Sep 2006



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Dr. Hubert Lienhard, Chairman of the Board of Voith Siemens Hydro Power Generation

Dear readers, dear friends,

The fact that the entire world needs energy for growth is undebatable. Over the past few months, however, this debate is yielding some interesting new arguments. We are trying to increase energy efficiency, but also energy production. At the same time, energy generation must not increase pollution. A combination that is close to impossible.

For this very reason, each and every form of energy generation must be evaluated for the benefits and impacts they have in each individual situation. Each country should balance its energy mix, based upon what makes the best sense in terms of economics, import policies, energy independence, use of domestic resources, etc.

What sounds simple very often is a highly complex and sometimes hard to solve issue.

As an equipment supplier for the hydroelectric industry, we still can do only one thing: promote hydro power as part of a multi-purpose solution that provides clean, emission-free generation, irrigation, drinking water supply and recreation. And, last but not least, the ability to store energy, in terms of pumped storage technology.

Pumped storage technology not only makes sense for clean, economical peaking power, but later in this edition of HyPower, you will find out what it has to do with soccer, too! We are a leader in this technology and are proud to be chosen for the latest European developments in pumped storage plants, especially in Austria right now.

In contrast to the many advantages that hydro power provides for developing and industrialized countries, political decisions concerning hydro power are obscure, especially in the framework of Kyoto mechanisms and IPCC work.

Hydro again is threatened with the burden of carbon charges even though it is an emissions free generator. This “playing” ground of discussions, compared to other fuels’ prices and emissions is simply bizarre.

Therefore, we remain aligned with the IHA to work through this political process and try to make our stand. We see hydro as the best option, to stand through this test!

Whatever your ideas and thoughts may be, I will be pleased to receive them at
Hubert.Lienhard@vs-hydro.com.

Kind regards from

In step with world championship Peak energy from pumped storage power stations

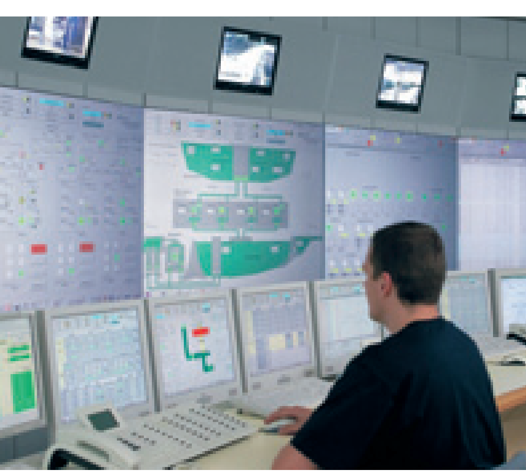

FIFA
TOSHIBA
FUJIFILM

World Cup 2006: The soccer players are in top form and so are the fans. But the cheering and nail-biting are not only going on in the stadium. Throughout the world more than a billion soccer enthusiasts followed the event on TV and large screens.

In the host country Germany alone, over 20 million TV sets were regularly turned on to the decisive knock-out phase. However, the matches are also intensively followed by the electrical load changes on the control center screens of the pumped storage power stations. What counts here is when the ball stops rolling: blowing the whistle signals the start of peak output.

Half-time. Before the players even get to the locker room, the fans are already preparing to make the most of the 15-minute break. That means getting a drink from the fridge, slipping a pizza into the oven and paying a necessary visit. Electricity consumption quickly reaches record levels when millions of people are all opening fridge doors, heating ovens and flushing toilets simultaneously.

The output of the base-load power plants cannot satisfy this high demand. Quick-reacting power stations are needed to supply extra energy into the grid. “When electricity consumption is high, that is during peak load periods, we can rapidly produce a maximum output of electricity”, says Dr. Klaus Schneider, the Technical Director of Schluchseewerk AG’s Wehr Pumped Storage Power Station in southern Germany. “In one sense, pumped storage power stations are the race horses of power plants, plus they are so flexible they can take on an emergency function for the grid almost instantaneously.” There is hardly an alternative to the pumped storage power station in extreme situations, such as the Soccer World Cup when several thousands of megawatts are used in a flash. By the time a coal-fired power plant boosts its operations, the soccer match would have long been over.



High performance on demand: From zero to maximum output in electricity refiner seconds

In contrast to slow reacting thermal power plants, pumped storage power stations can generate electricity very rapidly. For instance at the Wehr pumped storage power station it only takes about 100 seconds to start a turbine from standstill to full output. Other, very new pumped storage stations even make it in 20 seconds! As soon as electricity consumption surges with the end of the first half of the match, peak electricity is called in from stations such as the Wehr underground power station. The spherical valves at the turbines are opened, and water immediately flows down from the Hornberg reservoir, the upper storage lake one thousand meters above sea-level, into the turbines.

640 meters below, the rushing water impacts the massive blades of four Francis turbines arranged side by side in a huge underground powerhouse – twice as long as a soccer field. The power station generates almost a 1,000 megawatts under generator operations: in just under 90 seconds the output of a medium-sized nuclear power plant is thus made available.

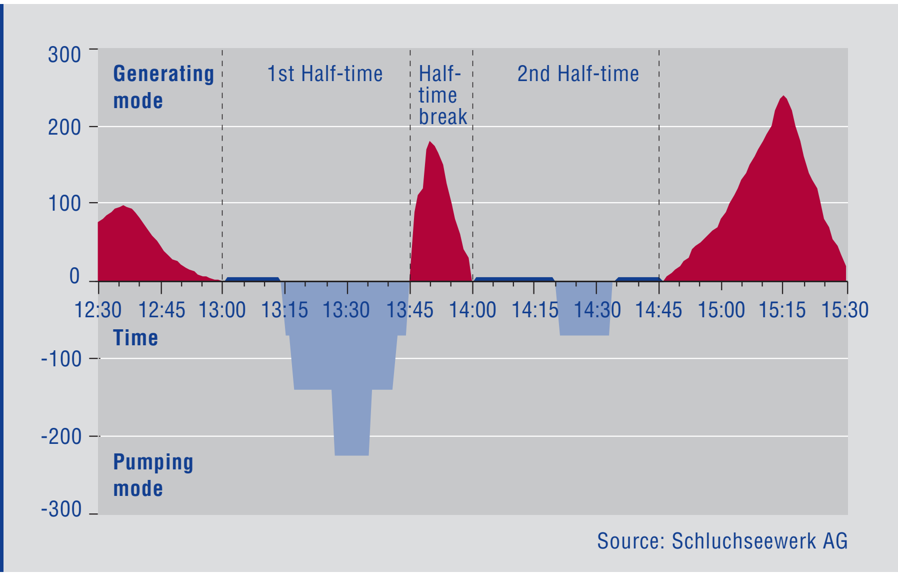
The Wehr pumped storage power station is part of a system of five pumped storage plants of Schluchseewerk AG, with 20 machine sets in all. This system is controlled from a central control center. The Schluchseewerk turbines can be supplied from 14 storage resevoirs. Thus, if needed, they can generate a maximum of 1,800 megawatts within a very short time. In the opposite direction, and in order to fill the upper reservoir, they can absorb a total of 1,548 megawatts from the electrical grid for pumping. In this way consumption peaks can be effectively absorbed.

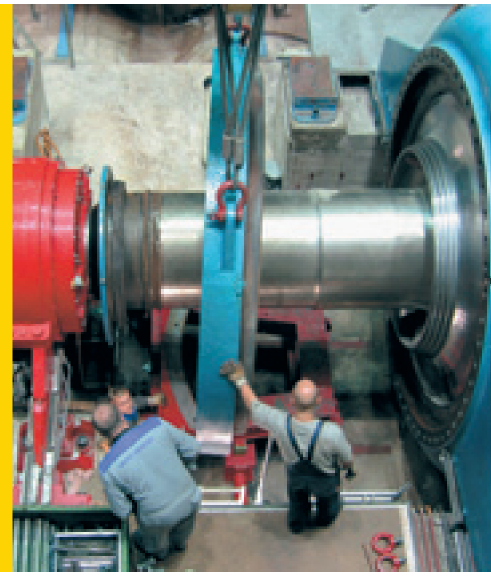
"Pumped storage is the only way to store electrical energy on a large scale"

explains Dr. Klaus Schneider of the Schluchseewerk AG.

The pumped storage power stations are not only the ideal peak electricity suppliers simply because they supply a maximum of electricity into the grid very quickly. Just as important is the capacity to rapidly decrease electricity production.

Electricity consumption drops sharply as soon as the referee blows for the second half to start and the soccer enthusiasts are again seated in front of their TV sets and screens. Any extra energy now





The peaking and decreasing of power during a match can clearly be followed on the control screen. Absolutely reliable and well-serviced equipment is the foundation.

being supplied to the grid could result in dangerous voltage overloads and frequency deviations. They, in turn, could damage sensitive electrical equipment.

While thermal power plants cannot shut down at short notice, hydroelectric power plants can run down their electricity production to zero very quickly. As soon as the teams in the stadium run back onto the field, the heavy spherical valves close, shutting off the flow of water from Hornberg reservoir, so that output is reduced to actual consumption. The second half begins – the electricity grid is stable.

Timing is vital: Surplus energy becomes peak electricity

After flowing through the underground turbines, the water from the Hornberg reservoir now flows through an underground tunnel into the lower reservoir – which was created by a dam on the Wehr a river upstream of the town of Wehr.

As soon as the soccer game resumes and the fans again concentrate on what is happening on the field, the water is pumped back to the upper storage lake.

"Our pumps can pump 144 cubic meters of water a second uphill over 640 meters"

explains Alexander Schechner of Voith Siemens Hydro, the hydro power specialist. At first glance this might seem a contradiction in terms. After all, the energy needed for pumping uphill is inevitably greater than the electrical energy which can be subsequently generated with this water. Some 1.3 kilowatt hours of electricity are needed to generate one kilowatt hour. However, this dual energy transformation of electricity into potential energy and back still makes sense from technical and economic standpoints.

"The interesting aspect is that when the machines are in pump mode, electricity is available at low cost in the grid. This is because other plants, such as coal-fired and nuclear base load plants, must always run. That is what makes pumped storage economical". As a rule, pumped storage power stations make use of base load periods when an excess of energy in the grid makes electricity very cheap – for instance, at night – to fill their upper storage reservoirs. These storage lakes filled by using cheap night-time electricity are then released through the turbines during peak load periods to generate expensive peak power.

A great one-two pass: Pumped storage power stations and wind energy

The day and night rhythm of generating and pumping operations is by no means the only operating schedule. Demand alone dictates the operating regime for the machinery. Even rapid operating mode changes are no problem for the Schluchseewerke power stations and their Voith Siemens Hydro machines.

“When, for instance, a thunderstorm suddenly occurs and people are switching on lights and needing electricity during a pumping cycle, the pumps can be shut down within a very short period and the power station can immediately return to generating operation”, explains Alexander Schechner.

The fact that pumped storage power stations can quickly react to shortages and surpluses in the electricity grid makes them ideal stabilizers. In 2004, they switched over 16,000 times between the different operating modes. The capacity of pumped storage power stations to supply both – energy as an electricity producer in the under generating mode, and “negative” energy as a consumer in the pumping mode – makes them highly suited for integrating the growing number of highly fluctuating energy producers, such as wind energy plants.
If there is a surplus of electricity, the pumped storage basins can be filled. And if there is a need, then energy is immediately on call: like a “water battery” in a sense.

Soccer World Cup: Electricity consumption tells of victory or defeat

In the dispatching centers, engineers know precisely when it is time to fill up or drain their “water batteries”. Even during the World Cup. Without knowing the result, they can tell from the electricity consumption curves if the German team has won or not. If they lost, electricity consumption immediately soars at the game‘s end. If they won, the peak loads only come some 15 minutes later – after all, cheering does take some time. But there is one thing the fans can rely on: the right temperature for the drinks is always on hand, no matter when they are taken out of the fridge.

The Wehr pumped storage power station in figures

Commissioned		1976	
Head	m	626	
Turbine type		4 x horizontal Francis	
Rated turbine output	MW	910	
Rated pumping capacity	MW	980	
Discharge at max. turbine/pump operation	m^3/s	160/144	
Delivery tunnel length	m	1,300	
Delivery tunnel diameter	m	5.53	
Rated annual generation in 2004	MWh	1,269,000	
Number of operating mode changes in 2004		16,375	
Storage lake		Hornberg reservoir	Wehr reservoir
Type of dam		Rockfill dam	Rockfill dam
Retention water level elevation	m over sea level	1,048	419
Storage content	million m^3	4.4	4.1
Storage lake length	km	0.7	2
Storage lake width	km	0.3	0.41
Catchment area	km^2	–	67.59
Height of the dam	m	40	40

Kaprun.

Pumped storage – the electricity refiner

The rising demand for peaking power is creating a completely new market value, which is also increasing the attractiveness of pumped storage power stations. This is particularly true at power stations where storage lakes already exist. As a result, there is no need for the otherwise often lengthy approval procedures and costly storage lake construction.

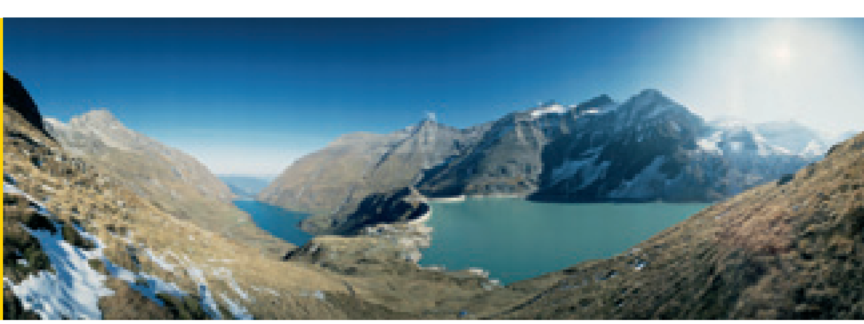
In addition, existing high-voltage power lines can be used with minor modifications, negating the need for new transmission lines and negative impacts on the surrounding environment. Construction of a power tunnel between the upper and lower reservoirs requires much less civil work than constructing a complete new hydro scheme.

In one sense, pumped storage power stations are electricity "refiners": They make use of low-price surplus electricity when consumption in the grid is low and use it to pump water from the lower into the upper storage reservoir. Later, this water is then used to generate valuable peak electricity when the requirement for electricity is sudden and high.

The objectives for new pumped storage plants, embedded in already existing water storage structures can generally be defined as follows:

- Power boost
- Rolling pumped storage
- Additional control energy
- Voltage control
- Frequency control
- Reactive power control
- Raising of secondary control and minute reserve (possibly also primary control)

Limberg: Upper and lower reservoirs.



Pumped storage power stations stabilize electricity grid

As the generation and consumption of electrical energy is not absolutely synchronous and there is always a surplus or lack of electricity in the grid, the provision of control power is another major constituent to guarantee the safe operation of transmission grids; something that can be very well fulfilled with pumped storage power stations. A distinction is made between primary control, secondary control and minute reserve, depending on the length of time of the variations – with the reaction speed being the most important quality feature.

Primary control

Primary control represents the reserve for momentary restoration of the power balance and stabilization of a continuous frequency following a malfunction. It, therefore, takes top priority. Up to 3,000 MW must be provided within 30 seconds or less. Pumped storage power stations are only suitable for primary control mode when designed for the so-called "hydraulic short circuit" operating mode, while connected to the grid.

Alternatives exist: Pump-turbines can consist of two machines, pump and turbine. With these two separate machines, the pump output can be routed directly to the turbine by valves with only a small energy loss being added to keep the pump in operation. If the need to absorb energy occurs, the pump is switched to reservoir consumption absorbing lots of energy while the turbine is shut down. If power is needed, the upper reservoir water is routed to the turbine. Another option with reversible pump-turbines could be that turbine operation mode would be that of a synchronous machine condensing in air, while the other mode would be spinning or pumping.

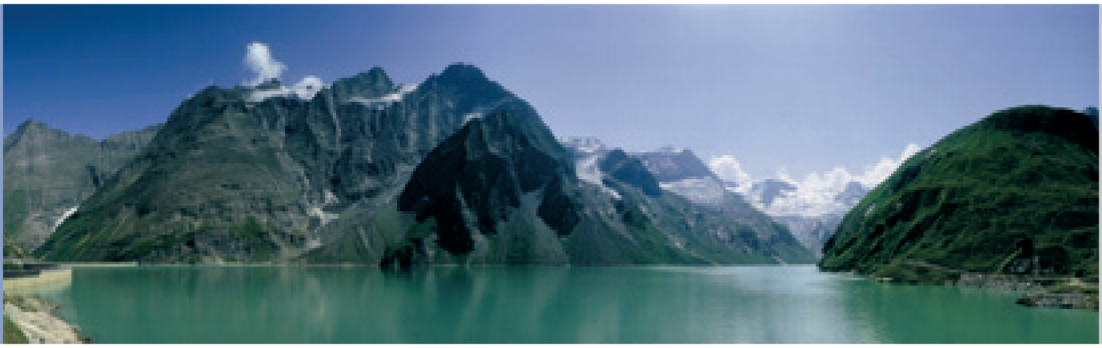
Secondary control

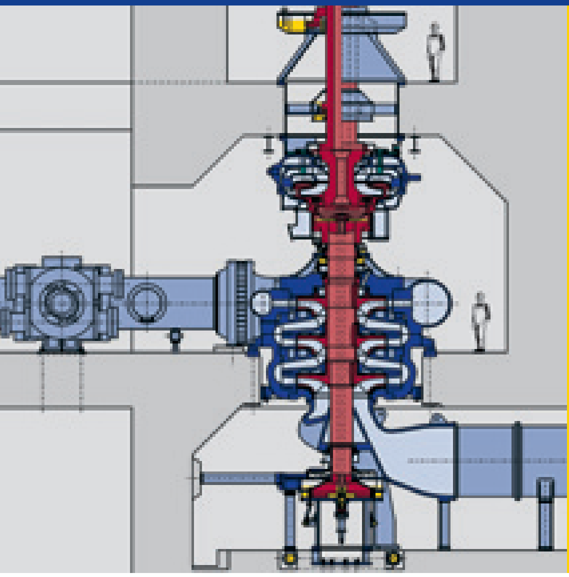
In the case of variations lasting longer, the primary control is replaced by secondary control after 30 seconds. It is used to control the then remaining frequency deviation. As a result, the primary reserve is again released and is once more completely available for further grid stabilization. Storage and pumped storage power stations are the main suppliers for secondary control purposes; they do not need to be connected to the grid.

Minute reserve

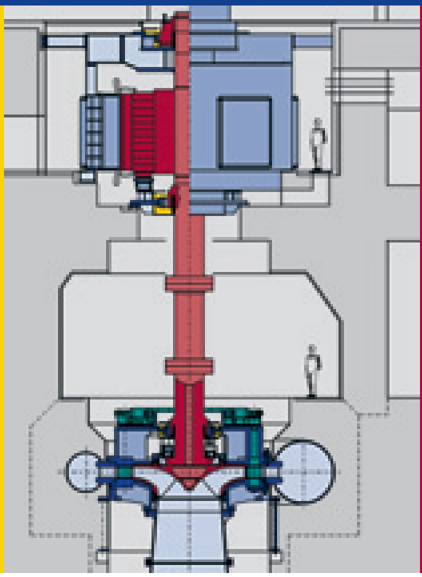
The minute reserve is drawn on when grid overloading is in excess of 15 minutes. Pumped storage power stations are very well suited for the minute reserve. To control grid variations, the power stations must be in a position to change their power with a gradient of at least 2% per minute of their maximum power. The provision of a minute reserve must correspond to the variation in the minute range. To this end, pumped storage power stations are extremely well suited, due to their broad power range.

Upper reservoir of Limberg.

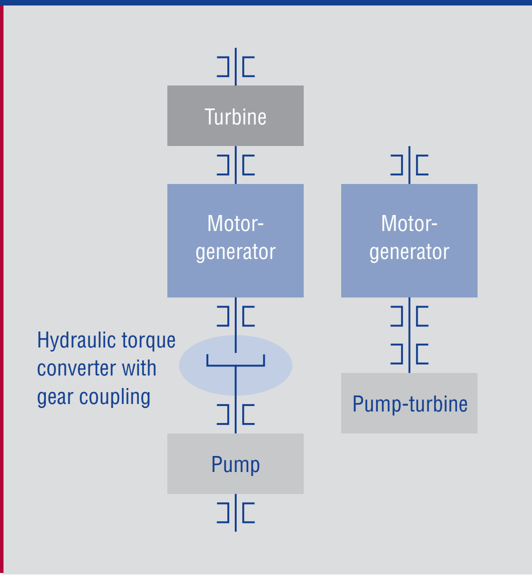




Cross section Kops II.



Cross section Limberg II.



Comparison of a separate pump storage arrangement (left) and a reversible pump-turbine (right).

New pumped storage power stations under construction in Austria

Voith Siemens Hydro is supplying equipment for two new and innovative pumped storage power stations in Austria: Kops II in Vorarlberg and Kaprun's Limberg II plant in the Salzburg area. In both cases, new power plants are being added to existing stations and will use the existing storage reservoirs.
The projects are, however, radically different from one another in terms of hydraulic machinery: Kops II is of the fomerly "classic" design equipped with separate turbine and pump sets, consisting of a Pelton turbine and motor-generator, a hydraulic torque converter (HTC) with gear coupling, and a multi-stage storage pump, while in Limberg II each motor-generator is directly linked with a reversible pump-turbine (see schematical comparison).

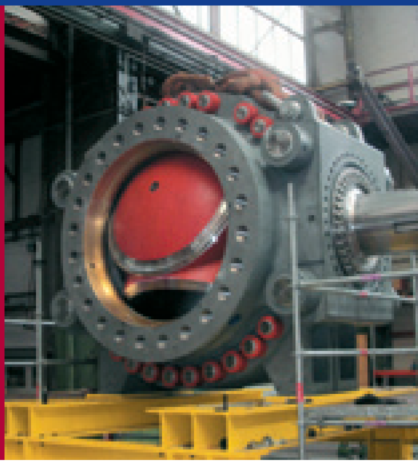
The classic concept: Separate pumps and turbines in Kops II

The classic concept with separate machines is being used in the Kops II plant due to the need for extremely rapid switching time between turbine and pump operation. This is because the Pelton turbine can be opened and closed very quickly and the storage pump – as a result of the hydraulic torque converter's effect – can be connected to or separated from the shaft system within seconds.

As two separate hydraulic machines, the rotational direction of the motor-generator can be the same in both operational modes. This solution may create considerable commercial value added to today's utility operators.

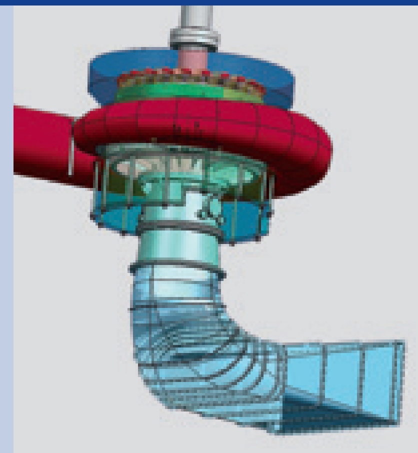
The primary control capacity from realization of the "hydraulic short circuit" is an additional benefit that may very well match the additional investment for equipment and civil construction. And so is the conservation of water that is recycled directly from the pump in the turbine.

Since pump efficiency drops quite rapidly when operation deviates from the optimum design parameters, but the turbine under partial load will still provide remarkable efficiencies, it might still be economical to operate the pump at full capacity using the low electrical surplus power in the grid, and to generate the power that the motor generator lacks, by deflecting some of the pump water flow in the turbine connected on the same shaft.



Spherical valve Kops II.

Pump spiral casing Kops II.



3D-pump-turbine Limberg.

Another enormous hydraulic short circuit benefit has recently been added: it is the quick response to the grid due to machine's constant synchronization with the grid at all times.

In Kops II, three machine sets with a combined output of 450 MW will be built for 820 m head. The HTC and storage pumps supplied by Voith Siemens Hydro as well as the spherical valves are the key components in the supply contract.

Since the HTC has a coupled pump rotor fixed to the generator shaft and a coupled turbine runner fixed to the pump shaft, it ensures a pump run-up time of only around 10 seconds. At the same time as the converter is filled with water, the turbine runner and with it the pump are accelerated to the rated speed and – with both runners at the same speed – a gear coupling is activated to connect the pump to the unit shaft. Simultaneously the converter is being emptied.

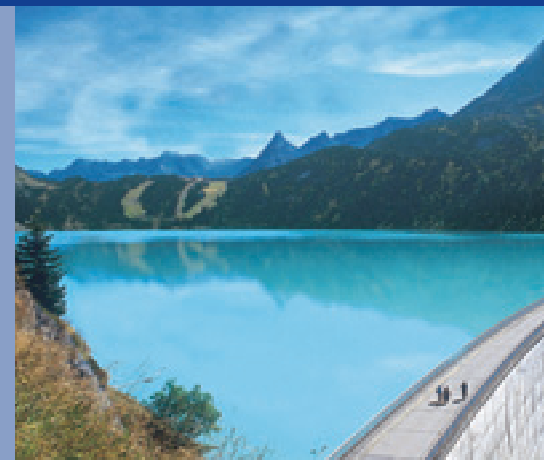
Voith Siemens Hydro has been compiling references for HTC since the 1950s. The Kops II power station operator Vorarlberger Illwerke (VIW) was in fact the first customer to receive a Voith HTC back then. The overall height of this arrangement necessitates more space in civil construction. This means higher cost to build the power house and for the mechanical section of four main components, compared with the reversible pump-turbine concept.

Compact dimensions and lower capital expenditure: Pump-turbines at Limberg II

Two pump-turbine/motor-generator sets will be installed at the Limberg II power station. Voith Siemens Hydro is to supply both pump-turbines. The two machine sets are designed for an overall 480 MW output at a head of 360 m.

This power house is quite compact, thereby reducing equipment and civil costs. Due to guide vane adjustability the pump is adjustable as a benefit, to help quick pump operation changes. Characteristic of reversible pump-tubines is the longer switch-over time from turbine to pump operation and vice versa. This is down to the air being used to expel the water in the turbine for restarting under pump operations, as the start-up equipment for the motor would not be in a position to do so with water. The rotational direction must also be changed, as this reversible machine operates in both, pump and turbine mode.

In Limberg II the solution of a reversible pump-turbine has proven to be the most efficient one: in comparison with Kops II, the Limberg II regulation requirements are not as sophisticated and complex; also, the more compact design of the machine and consequently civil construction, results in lower investments. In both cases, the selected design for the pumped storage arrangements was chosen as an optimum technical solution that – in the context of grid regulation demands of each plant – results in the best possible return for the operating utility.



Kops II spherical valve transport in December 2005.

Kops storage lake.

Last but not least: Perfect integration into the landscape

Except for the power house entrances, nothing will be visible from the two plants when operations start at both Kops II and Limberg II pumped-storage stations. They are underground cavern stations. Everything, including piping, is underground and proof of the high importance of landscape preservation in the areas affected.

Both plants reveal Voith Siemens Hydro's expertise and innovativeness in the field of pumped storage and this field will continue to gain importance over the next few years, due to its benefits for environmentally friendly and reliable energy and, moreover, its high flexibility and stabilizing qualities in electricity grid operation.

Transport summary

Butterfly valve delivery for Kops II: 100 tons through the Alps

- Two identical butterfly valves arranged one behind the other are to be installed at the entrance to the delivery line directly at the Kops storage lake: an inspection valve closed during work and inspections and an operational valve to be kept constantly open during normal operations. Both 4.9 x 6.5 x 1.5 m shut-off valves were manufactured in Voith Siemens Hydro in São Paulo (Brazil). The existing Kops storage lake was emptied in spring 2006 for the purpose of having these valves installed.
- The first of the two butterfly valves entered the port of Hamburg on December 10, 2005, after a 10,000 km ocean journey. It was then sent by road on a 12-axle special transporter to Kops. A real challenge was presented by having to deliver the 92-ton butterfly valve to the site along a narrow, 20 % downhill gradient winding road. Despite the wintry alpine conditions, this feat was mastered with the help of a special carrier which over the entire stretch was escorted by an Austrian army salvage tank. The other butterfly valve for Kops is already on its way to the project site.

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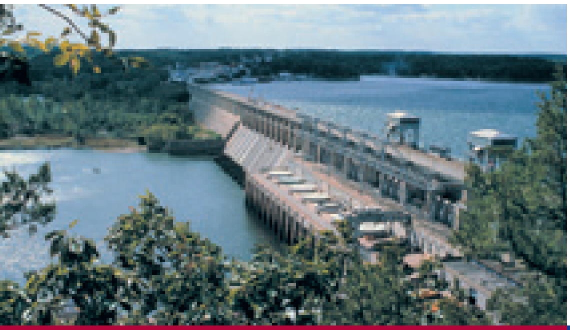
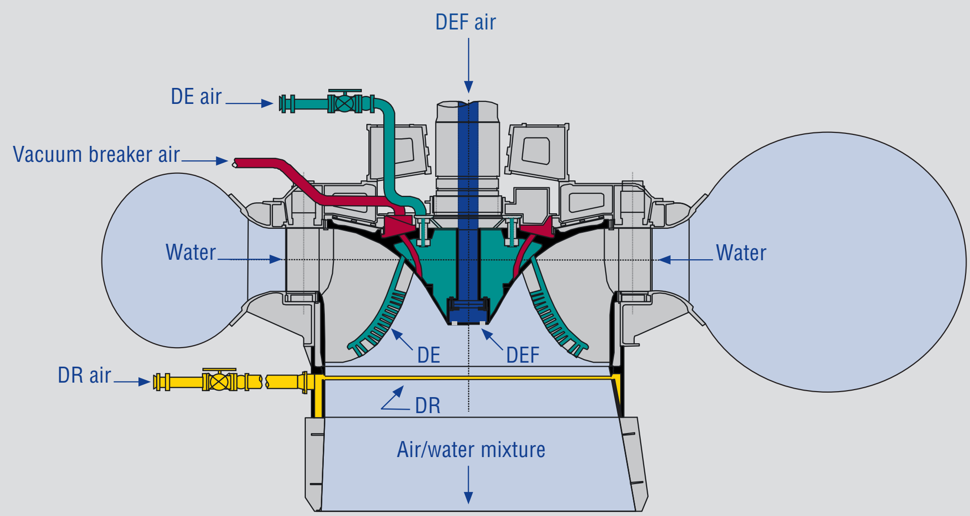
New aerating turbine technology for Osage plant, Missouri, USA

AmerenUE of St. Louis is upgrading its Osage plant. Voith Siemens Hydro will supply and install upgraded components for units 1 and 7 of the plant which is located at the Bagnell Dam on the Lake of the Ozarks in southwest Missouri. The principal goal of the improvements is to substantially raise the oxygen level of the water in the tailrace and at the same time increase turbine output.





The scope of work includes turbine model tests, new aerating Francis runners, new shafts, turbine rehabilitation and disassembly/reassembly of the machines. Turbine output will be increased by approximately 30 %. However, the special feature of the work is the proprietary – and patented – aerating design of the runners.

This unique through-the-blades method of admission of air into the draft tube provides substantially better results than other more conventional approaches, both in the effectiveness of oxygen uptake and operating efficiency when aerating.

The decision by AmerenUE to use the turbines' runners to achieve the mandated oxygen uptake in the river was made only after intensive study of several other non-turbine solutions as well as the more conventional turbine solutions.

The work is scheduled to be completed in the spring of 2008.

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Aimorés inauguration with (left to right): Brazil's President, Lula da Silva, Aécio Neves, Governor of Minas Gerais, Roger Agnelli, President of Vale do Rio Doce and Djalma Bastos de Moraes, President of CEMIG.

Corumbá site view.

More than 1,500 MW for Brazil in 2006

Aimorés launched

The Aimorés hydroelectric power plant of Eliezer Batista, in Minas Gerais, Brazil, was inaugurated this summer. It began commercial operation already in 2005 with three Voith Siemens Hydro 110 MW-Kaplan turbines, manufactured by the company's Brazilian facility.

Aimorés provides 330 MW of installed power for the Brazilian electric system, helping to compensate for the deficit in the western region of the state of Minas Gerais and the north of Espírito Santo. Approximately € 400 million were invested by the utility out of which a portion was awarded to the Voith Siemens Hydro Power Generation equipment contract.

As part of this contract, nearly € 8 million had been invested in water supply and sewerage systems, the restoration of 23 km of the Vitória-Minas railway, and in improved health and public security and education systems.

The President of Brazil, Luís Inácio da Silva, Aécio Neves, the Governor of Minas Gerais, Roger Agnelli, President of Vale do Rio Doce, and Djalma Bastos de Moraes, President of CEMIG attended the inauguration ceremony.

Corumbá IV on the grid

Under a turnkey project, Voith Siemens Hydro, São Paulo, will supply two 64.8 MW-Francis turbines, valves and other mechanical and electrical equipment, including technical services for Corumbá IV. The hydro power plant will generate energy and supply water to the population of the capital Brasilia and several neighboring cities.

Corumbá IV is powered by the two units with an installed overall capacity of 130 MW and will increase twofold the delivery of potable 8,000 l/s to Brasilia. The plant will provide uninterrupted electricity for 250,000 inhabitants, representing 15 % of the city's energy consumers.

Peixe Angical runner in São Paulo workshop.

Irapé site view.

Three units for Peixe Angical

Two of three 150 MW-Kaplan turbine generators were put into commercial operation in June at Enerpeixe S/A's Peixe Angical power plant on the Tocantins River in the state of Tocantins, Brazil. The third unit was commissioned in August of this year, taking up commercial operation in the beginning of September.

Capim Branco I

The last of the three 80 MW Francis turbines began commercial operation in May 2006. The first two were commissioned in February and March of this year. At full capacity, the Capim Branco I hydroelectric power plant generates 240 MW of clean renewable electricity.

Irapé inaugurated

The Governor of Minas Gerais, Aécio Neves, and the President of CEMIG, Djalma Bastos de Morais, again were present at the inauguration ceremony for the Irapé hydroelectric power plant (Juscelino Kubitschek). Three 120 MW Voith Siemens Hydro Francis turbines provide a total of 360 MW of installed capacity at Irapé. It is considered one of the most important enterprises of Vale do Jequitinhonha, due to its importance for the social and economic development of this valley.

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Inauguration and commencement of erection at Omkareshwar

At a solemn ceremony, Voith Siemens Hydro Power Generation, along with the Project Owner Narmada Hydroelectric Development Corporation (NHDC) marked the beginning of installation work at the 520 MW Omkareshwar hydroelectric project.

The Omkareshwar project, in the central Indian State of Madhya Pradesh, is located on the Narmada River. The contract to build this power station was signed between NHDC and the Consortium of Jaiprakash Associates and Voith Siemens Hydro in July 2003. Work on this project started in October of the same year.

Since April, “pit free dates” have been achieved for four additional units. At the same time, erection work is presently in full swing on five of the eight 65 MW units. Tower erection in the switchyard is also in progress. Acknowledging the good progress of work at site, the customer has opened a dialogue for accelerating the completion of the units as compared to the agreed-upon schedule.

Hydro power enhances India’s energy security and is ideal for meeting peak demand. Less than one fourth of the vast 150,000 MW hydro power potential has been tapped so far in India.

In fact, the share of hydro generation in India has gradually declined over the past 25 years. India’s goal is to have 40 % of its power generation from hydro power; currently it is about 25 %.

Historically, Voith Siemens Hydro has been active in India’s hydro power sector. In 1911, the company supplied four generators and auxiliaries for the Khopoli Power House of Tata Hydro-Electric Power Supply. This power house is still in operation, reflecting Voith Siemens Hydro’s dedication to quality and technology.

At present, Voith Siemens Hydro is also actively involved in the construction of the 450 MW Baglihar hydroelectric project for Jammu and Kashmir Power Development Corporation.

Voith Siemens Hydro Power Generation, along with its Indian business unit, founded in July 2002 in New Delhi, is committed to the continued development of hydro power in India.

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Omkareshwar project site.

Honorable Chief Minister of Madhya Pradesh, Shri Shivraj Singh Chauhan addressing the gathering.

Ritual during commencement ceremony.

Site view of Mequinenza hydro power plant.

Modernization contract for Mequinenza in Spain

Voith Siemens Hydro's scope of supply in this contract comprises the modernization and upgrading of four vertical Francis turbines (4.3 m runner diameter) with a rated capacity of 81 MW each, four 90 MVA generators (8.3 m rotor diameter) and four high voltage transformers of 95 MVA.

In order to maximize the future plant revenue, Voith Siemens Hydro, in close cooperation with the owner, Spanish Endesa, developed a techno-economically optimized hydraulic design that will ensure the best mix of energy production, storage capability and installed capacity. Through the modernization of the Mequinenza hydro power plant, the maximum output will be increased by 30 % to 324 MW at a rated head of 47 m and by 20 % to 384 MW at a maximum head of 53 m.

Furthermore, the new design provides for smooth operation of the equipment from speed-no-load to maximum-full-load operation, which will ensure maximum operating flexibility.

Due to its upper reservoir storage capacity, which is Endesa's largest in Spain, Mequinenza always was and – through the liberalization of the energy market in 1998 even more has become – one of Endesa's most important hydro power plants in terms of supplying energy during peak demand periods.

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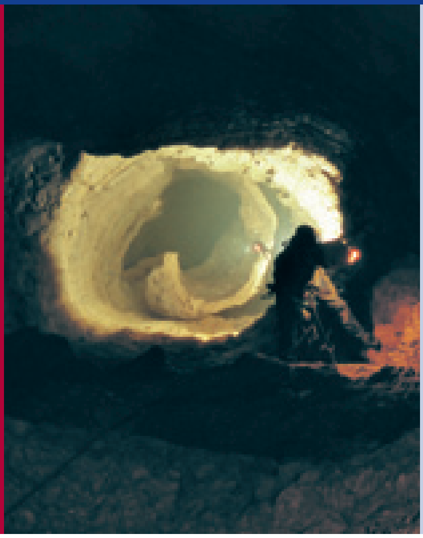

Arabika Massif, Caucasus Mountains, Georgia.

Krubera Cave in this massif is the deepest cave in the world with a depth of 200 m.

Enguri – Unit No. 3 commissioned

After 14 years of standstill, unit No. 3 of Enguri hydro power station is generating electricity again. Voith Siemens Hydro is rehabilitating three of the five 306 MVA hydro power units. The Enguri hydro power station is located on Enguri River in Georgia/Abchazia.

Voith Siemens Hydro is supplying the stator core, the water cooled stator bars and the electrical systems including the turbine governor, automation system and low volt-equipment. Commissioning of unit 2 is expected for January 2007, the last unit will be finalized in January 2008. With an installed capacity of 1,300 MW, Enguri will have an annual energy production of 45,000 MWh, representing 40 % of Georgia's electricity generation.

The project is financed by loans from the European Bank for Reconstruction and Development (EBRD) and the European Union.

The project will alleviate the critical power shortage in Georgia at possibly low cost and will enhance the environmental benefits of the Enguri power facility. It shall also support the government's ongoing privatization program, improving the commercial operation of the Enguri hydro power station, laying the foundation for its privatization.

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Promising future for ocean energy

Another important step in the development of ocean wave energy for commercial application has been achieved by Voith Siemens Hydro and its Scotland-based subsidiary Wavegen: Two new wave energy projects are on the way.

British RWE-branch npower renewables and Wavegen have entered into an agreement to build a 3 MW wave power plant in the outer Hebridian Islands of Lewis and Harris.

The technology used in the new plant would be based on Wavegen's Limpet plant on the Island of Islay, which is currently the world's only commercially operated wave power plant. For several years, it has been supplying electricity to the grid that powers private households on the island.

In 2000, the plant was installed with a capacity of 500 kW.

This new project would be integrated into a new breakwater, which would considerably reduce the cost of civil construction and, at the same time, provide 1,500 households with power and build a new harbor for the local infrastructure.

Possibilities for wave energy have also been opened up in continental Europe: Here, Voith Siemens Hydro, in cooperation with EnBW of Germany and the government of the Federal State of Lower Saxony, Germany, intends to develop and construct the country's first wave power station.

The envisaged nominal capacity of Germany's first near-shore power plant is planned to be 250 kW, resulting in annual electricity generation of 400 MWh – sufficient for 120 households.

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Wavegen's Limpet plant in Islay.

Hydro power and greenhouse gas emissions

The hydro sector continues to face accusations that hydro power contributes to global warming. Cumulatively, the message is that freshwater reservoirs are part of the climate-change problem, rather than part of the solution, especially in warmer climates where the carbon cycle is more active.

Development of guidelines-within IPCC

At its meeting in Mauritius in April 2006, a task force of the Intergovernmental Panel on Climate Change (IPCC) put forward its draft 2006 Guidelines for National Greenhouse Gas Inventories for internal adoption.

The draft included a section on flooded lands, allocating default emission factors of carbon dioxide (CO_2) for all new reservoirs. Different factors were proposed according to climate type. In addition, the intention was made clear to take the same approach for methane (CH_4) emissions from reservoirs.

On behalf of its members, the International Hydropower Association (IHA) wrote to the IPCC Executive and also to various government contacts to express concern about this development. IHA's position was that the science on which IPCC had been advised was based on gross emissions collected by the 'flux' method on a small sample of reservoirs.

It was argued that the observed gross emissions did not subtract emissions that would have occurred naturally within the carbon cycle. While there was no consensus as to the calculation of any anthropogenic contribution, there was certainty that water in the drainage basin was a major vector in the natural carbon cycle and that significant emissions would occur irrespective of the presence of a man-made reservoir. Therefore, the IPCC advisors had substantially overestimated the contribution of greenhouse gas (GHG) resulting from freshwater reservoirs.

During the IPCC meeting, several country representatives argued against the 'flux' method presented in the draft. Ultimately, another approach, the 'stock' method, was put in place of the original text (which was moved to an appendix). The stock method requires the 'total submerged living biomass carbon stock' to be assumed to be emitted as CO_2. The section includes an acknowledgement that the emissions are progressive (multi-year) and "may lead to overestimates". No default emission factors were recommended, but an equation was given to establish a value based on the type of inundated vegetation cover. The IPCC Guidelines were then adopted before the close of the Mauritius meeting.

Proposal of IPCC Guidelines to UNFCCC

Following the Mauritius meeting, IPCC presented its 2006 Guidelines to the Subsidiary Body for Scientific and Technological Advice of the UN Framework Convention on Climate Change (UNFCCC) in Bonn, May 2006. During this meeting, several governments expressed reservations about the new Guidelines.
IHA was represented in Bonn and also delivered a formal note of concern. IHA urged extreme caution in the use of the guidelines.
The outcome of the discussions appears to be that UNFCCC will not be requiring its Designated National Authorities to put the new guidelines into practice.

IHA proposed that parties must take this opportunity to find a method that analyses freshwater reservoirs in terms of their net impact on the whole drainage system, according to a life-cycle approach. The method needs to measure not only outputs of GHG, but also carbon inputs, transport and accumulation in the drainage basin. Clearly the current 'stock' and 'flux' approaches do not fully address this. IPCC appears to be looking to make a new start on this subject, with a wider community than in the past. At the same time, the hydro sector must engage in this issue with more commitment.

Hydro in the Clean Development Mechanism

In parallel with the afore-mentioned, IHA became aware that the Executive Board of UNFCCC's Clean Development Mechanism (CDM) had introduced new criteria for hydro project applications.
T criteria are based on thresholds in terms of power density (W/m^2), as follows:

i. Projects with power densities (installed power generation capacity divided by the flooded surface area) less than or equal to 4 W/m^2 are excluded;
ii. Projects with power densities greater than 4 W/m^2 but less than or equal to 10 W/m^2 can be eligible, but with an emission penalty of 90 g CO_2eq/kWh;
iii. Projects with power densities greater than 10 W/m^2 can be eligible, without penalty.

In response to this, IHA wrote to the CDM Executive to argue that the criteria would inappropriately exclude the majority of hydro power projects.

IHA research indicated that a power density of 4 W/m^2 was well above the international average for hydro power, while the vast majority of the gross GHG emissions from reservoirs were significantly lower than 90 g CO_2eq/kWh.

Again, IHA argued that gross emissions did not subtract emissions that would have occurred naturally, and that emissions would have occurred with or without the inclusion of a hydro power scheme.
The conclusion being, that the CDM criteria grossly overestimated the contribution of greenhouse gas resulting from hydro generation.

An example was presented in relation to testing on a scheme in Norway that would technically fall into the CDM category 'ii'. It was demonstrated that the proposed CDM allocation overestimated the measured gross emissions by a factor of 15.

Clearly, the CDM error is even higher as a significant proportion of the measured gross emissions would have occurred naturally.

For the CDM Board Meeting in July 2006, IHA requested consideration be given to its opinion that the new CDM criteria places hydro power projects at an unfair disadvantage in terms of eligibility within the Clean Development Mechanism.
IHA has also offered to provide further input on the impracticality of the criteria, regardless of the power density thresholds.

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European branch through HEA-E in Brussels

June 1, 2006, marked the foundation of the European branch of Hydro Equipment Association Europe (HEA-E) in Brussels.

The association of hydro equipment suppliers (HEA) has taken an important step on the way to strengthening hydro's presence towards the European Union commission. "We are confident that with HEA-E the interests of all hydro equipment suppliers in the European Union can be represented much better", said Jean-Pierre Corbet, who will serve on HEA's Board of Directors for the newly founded European branch of the organization. Currently, hydro power contributes to 95 % in the renewable energy generation mix, worldwide.

In their effort to improve hydro power's global image, both industry associations, HEA and the International Hydro Association (IHA), have paid little attention to the European Union activities in the past. The newly formed HEA-E will bundle the interests of smaller equipment suppliers. Among these companies are Mecamidi (France), Litostroj (Slovenia), and Stellba (Germany).

Along with the HEA's founding members Alstom Power Hydro (France), Voith Siemens Hydro Power Generation (Germany) und VATech Hydro/Andritz (Austria), the new members of HEA through this new chapter will work to cooperate with the European Small Hydro Association (ESHA) as well as with the European Renewable Council (EREC) to represent the interests of the whole hydro industry on a European Union level.

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Kiambere Kenya

Two vertical Francis turbines and generators

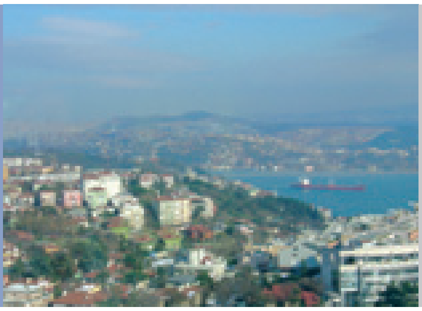
Kenya Electricity Generation Generation (KenGen) Company selected Voith Siemens Hydro in Germany to upgrade the Kiambere hydro power station in Kenya.

The scope of supply includes the upgrade of two vertical Francis turbines from 72 to 84 MW each, the improvement of the generator air-cooling system, new excitation systems, digital governors and the elimination of existing cavitation problems. Kiambere hydro power project is located in Kenya's green central highland on the Tana River. Recommissioning of the upgraded plant is scheduled for June 2008.

The upgrade project is part of KenGen's mission of keeping in tune with the latest technologies.

Uluabat Turkey

Turnkey supply for Turkish Uluabat hydro power plant



Voith Siemens Hydro St. Pölten, Austria, together with Siemens Turkey, received an order from AK Enerji to supply the complete electro-mechanical equipment, erection and commissioning for its Uluabat hydro power plant. Voith Siemens Hydro will be responsible for the supply of two Francis turbines and generators (50 MW/50 MVA each at 600 rpm), spherical valves and turbine governors, excitation systems and the complete control protection system of the plant. The contract is valued at € 15 million. The Uluabat hydro power plant is located in the western part of Turkey and will begin operation the end of 2008. This is the second turnkey project Voith Siemens Hydro in Austria has provided for private development in Turkey in the last six months. The first was Akköy I.

Si Lin China

Successful model acceptance test for Chinese project

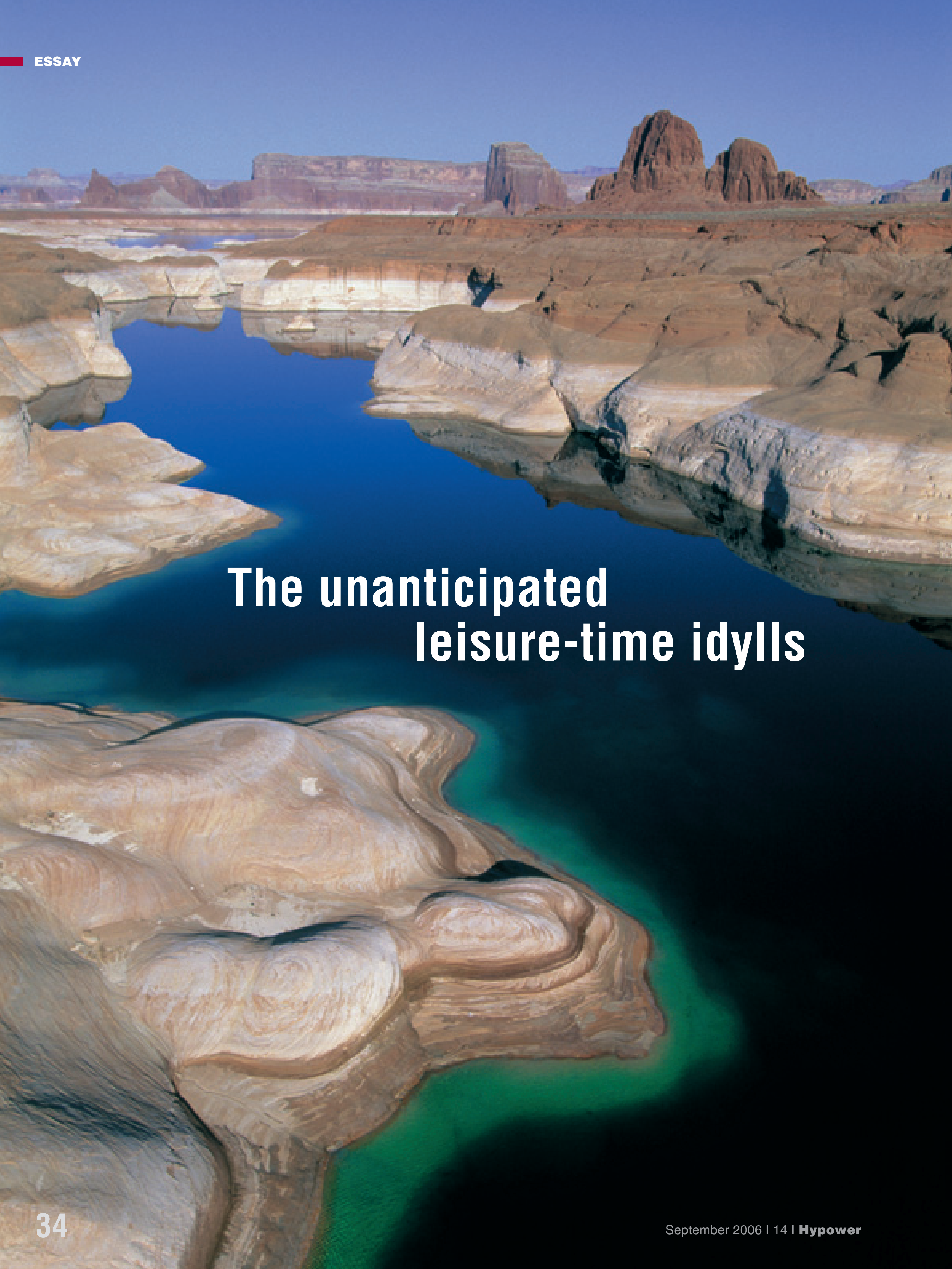
The model acceptance test for Si Lin project in China was performed successfully in Voith Siemens Hydro's Corporate Technology facilities in Heidenheim, Germany. When complete, this project, located on Wu Jiang River in China's province Guizhou, will have four 268 MW Francis turbines. The test was witnessed by experts of the customer Guizhou Wujiang Hydropower Development Company and its design institute Guiyang Hydropower Investigation Design and Research Institute. The model turbines, designed and optimized for Si Lin's operational requirements were extensively tested and the results fully met the contractual guarantees. With that, the final step of the hydraulic development now marks the beginning of detailed engineering and manufacture. The runners for Si Lin will be manufactured on site as their dimensions exceed conventional transportation requirements.

Chilatán Mexico

Small Hydro at Chilatán generates power

The Chilatán small hydro plant, owned by PEO – Provedora de Eletricidade de Occidente S.A. de C.V., recently went on line. The US$12 million of this EPC contract see the supply two 7 MW Francis turbines, including the power station design and construction.

Chilatán, in Jalisco state, is located on the Tepalcatepec River, 300 km from Morélia city, in western-central Mexico. The project will stimulate and accelerate the commercialization of renewable energy and, at the same time, will satisfy the growing energy demand in Mexico. Energy consumption is growing at about 6 % per year. The power station was installed to take the advantage of using an about 20 years old irrigation dam.



The unanticipated leisure-time idylls

Pumped storage reservoirs are establishing themselves worldwide as modern-day free-time hotspots with high appeal to tourists.

Karsten is a globetrotter, a modern globetrotter. He is one of those who, at 42, has visited every continent on the planet, likes taking photographs and reports on his experiences on his Internet homepage – that's when he's not skydiving, bungee-jumping, rafting or canyoning.
In early 2000 he travelled to Lake Powell and the Colorado's most spectacular loop, Horseshoe Bend: "The view of the Colorado far below, shimmering green, is truly phenomenal. The canyon walls are almost vertical, and fall several hundred meters. It is possible to make out tiny motor boats plying the river."
It all sounds idyllic. And because it is so idyllic, Karsten was not alone at Lake Powell. The dry, sunny climate and the wealth of recreational opportunities attract more than three million vacationers every year to the man-made lake in the US state of Arizona.

Lake Powell owes its existence to the Glen Canyon Dam. It was built in the middle of the Colorado River to generate power to provide seven US states and Mexico with water from the lake. Ladybird Johnson opened the Dam in 1966 and it took 17 years before Lake Powell, named after explorer Major John Wesley Powell (1834-1902), was completely full. Lake Powell became an enormous reservoir with a coastline of just under 3,200 kilometers and almost 100 side canyons. It boasts both large bays and expanses of water, not to mention hidden beaches, peaceful localities and slot canyons. Many of these canyons are just wide enough for a boat and their rock-face walls are well over 100 meters high. With houseboat holidays, concealed beaches, excellent fishing and water-skiing, the Lake's contrasts captivate millions of visitors every year. Lake Powell – the unanticipated leisure-time paradise.

Horseshoe Bend.

Lake Baldeney in Germany.

Although originally created to harness the power of water for the purposes of generating electricity, storage lakes are now cashing in on changed trends in modern-day tourism. Studies confirm that people are increasingly seeking adventure and inspirational nature experiences in their leisure hours.

The trend is moving from organized sports for the masses, for example, to extreme, outlandish and specialized leisure-time activities.

It is no surprise that hydro power plant reservoirs are gaining ever greater importance as today's recreational reservoirs having huge appeal to tourists.

In Germany for instance, in the spa town of Schluchsee in the Black Forest, Schluchseewerke AG, founded in 1928, built a 64-meter-high dam near Seebrugg in cooperation with the Schluchsee power plant group. The gravity dam prevents natural outflow from the original Schluchsee. Following completion of the dam, the water level was 30 meters higher, thereby creating a reservoir with a capacity of 108 million cubic meters. When full, the reservoir has a surface area of 514 hectares, making the Schluchsee the largest lake in the Black Forest.

The towns surrounding the lake, which in 2005 was awarded the title of "Rambling Location of the Year" at Europe's largest tourism trade fair, the CMT in Stuttgart, are not shy in promoting their best asset: "Whether sailing, surfing, rowing, diving, swimming for relaxation or for fitness – anyone who wants to enjoy water sports under the pine trees of the Black Forest will find the ideal conditions at Schluchsee. Most importantly, the Schluchsee is extremely clean. According to the German consumer protection organization, Stiftung Warentest, the Schluchsee has been one of the cleanest swimming lakes in Germany for many years." Motor boats are prohibited. But canoeing, sailing, surfing, swimming and diving in the reservoir are all allowed.

A few hundred kilometers to the west, south of the city of Essen, in the navigable stretch of the Ruhr River, is Lake Baldeney. It was dammed in 1931 as a water supply reservoir and to treat the water of the Ruhr. Today it has a capacity of around 7.6 million cubic meters. Rowing clubs and sailing and surfing schools make good use of the large lake, which has a surface area of some 2.7 square kilometers. Once a year, the elite among German sailors meet for "Essener Woche", the largest German lake regatta. The 14.7-kilometer circuit around the lake attracts inline skaters, walkers and cyclists.

At the beginning of 2000, Lake Baldeney in Essen was awarded second place in the "Ruhr Leisure-Time Barometer" for the most popular spare time destinations. Jörg from Essen can confirm this. He writes: "It's really super! What's this about the old Ruhr region? Lake Baldeney with its fantastic opportunities for young and old gives us Esseners something to be proud of! Just go there!"

Voith Paper

A new era in paper research has begun at Voith Paper in Heidenheim. Currently, it offers a unique service to its customers. In the new Voith Paper Technology Center (PTC), Voith Paper customers can experience a new dimension in paper technology. They can use the test apparatus to produce paper according to their own specifications and can hold the original in their own hands just a short time later.

The technology is enabling renowned companies such as BASF, Siemens, OMYA and Cargill to conduct independent experiments to examine, for example, the effect of chemical additives in paper production. “With the PTC, Voith is opening a new chapter in customer-orientated research and development. It is possible to research everything that affects the quality of the paper and its production process,” said Voith AG Chairman Hermut Kormann at the official opening of the PTC in Heidenheim on 11th May 2006. Voith AG is investing € 75 million in the Voith Paper Technology Center.

Voith Industrial Services

Voith Industrial Services carries out all maintenance, repair, service, and optimization activities at Münzing Chemie. The group division performes the services with employees of DIW and Voith Industrial Service Indumont and its partner regelmatic GmbH.

DIW handles the maintenance of all administration, production and warehouse buildings and is also in charge of routine cleaning and mail service. The Voith production logistics experts service filling systems, raw materials stocks, shop floor vehicles and ensure that all production parts are in the right place, at the right time in the right quality.

Münzing and Voith pursue the goal to significantly reduce maintenance expenditures and guarantee maximum availability of the production plant at the same time. The adherence to the extensive legal regulations of the chemical industry has highest priority.

Voith Industrial Services, a group division of Voith AG, is one of the leading providers of technical services for key industries. With over 150 business locations worldwide and over 15,000 employees, it posted sales of about € 700 million in 2006.

Voith Maxima® 40 CC.

The legendary high-speed railcar VT 08 in 1954...

...and today.

Voith Turbo – a winning history

Today's Voith Maxima locomotive

Voith Turbo Lokomotivtechnik, a subsidiary of Voith Turbo in Kiel, has unveiled the design of its new diesel-hydraulic six-axle locomotive: the Voith Maxima® 40 CC.

Voith Turbo Lokomotivtechnik is currently in the process of developing and building a locomotive for heavy goods transport. With an optional rail energy supply system, this locomotive will also be suitable for passenger services. With an engine output of 3,600 kW, the locomotive can be geared to maximum speeds of 120 to 160 km/h. Power transmission will be provided by dependable Voith components. The locomotive will be the most powerful diesel-hydraulic vehicle of its kind in Europe.

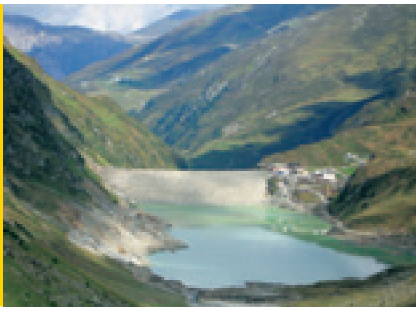
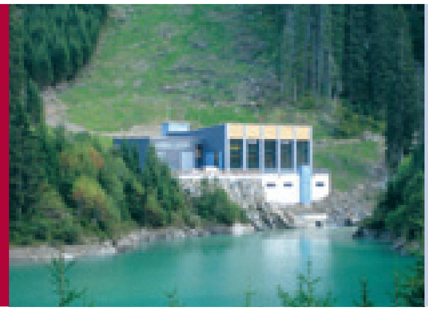
Voith Turbo's expertise in the rail sector has been making history for some time. Here is another historical milestone to ponder, a milestone that remains more pertinent to the World Cup than one would have thought.

A special train for soccer players in 1954

52 years after the German team won the World Cup soccer tournament in Switzerland, the legendary VT 08 high speed diesel train is still travelling around Germany. Hydrodynamic power transmission made this high-speed train indestructible. The most spectacular event for which the VT 08 was called into service was the homecoming of the national team from Berne to Germany. Hundreds of thousands of supporters crowded into railway stations as the train travelled from Spiez to Munich. The movie "Das Wunder von Bern" brought the legend back to life in 2003.

For the 2006 World Cup, the train again was deployed on numerous special excursions, demonstrating the long lifetime of the original hydrodynamic components.
Both power cars were equipped with the LT306r transmission from Voith. With an annual mileage up to 146,000 km the VT08 was a symbol of German long-distance travel in the 1950s.

For Voith Turbo, this was a milestone in the history of transmission development. Work from then on focused on ongoing development in the area of railcar and locomotive transmissions and optimizing of their hydrodynamic circuits. Today, Voith Turbo can look back on more than 70 years of experience and almost 40,000 turbo transmissions – a world record!


Renewables made in Germany

A movie, intended for business audiences from countries with great interest in the development of renewable energies and an overview of German technology in this area is currently provided by the German Energy Agency (Dena).

Dena's mission is to promote the development of sustainable energy systems with a high emphasis on renewable energy sources.
To this end, Dena initiates, coordinates and implements innovative projects and international campaigns. Part of the current media campaign for renewable energy is the new image film.

It shows the various ways of generating renewable energy – hydro included – and the overall expertise of German companies in this field.
Hydro power, in the film, is represented through Austria's Braz hydro power plant in St. Anton, a project with equipment supplied by Voith Siemens Hydro in 2004.

For further information

- www.renewables-made-in-germany.com

IAHR Symposium on Hydraulic Machinery and Systems will be held in Yokohama

The 23rd IAHR Symposium on Hydraulic Machinery and Systems will be held in Yokohama, October 17-21, 2006.

The Symposium sees IAHR‘s focus in the context of energy generation for the future: World population is expected to expand to 9 billion by the middle of this century, about 1.5 times the present level. At that time, water and energy will be among the most critical global issues for the sustainable development of the future human population. Hydraulic machinery and systems are the key components for the sustainable development of water resources, for hydro power production, and for various transport processes of the water. For more effective and efficient utilization of hydraulic machinery and systems, it is important to exchange up-to-date information on Research and Development (R&D), Numerical Analysis, Design, Operation and Monitoring of hydraulic machinery.

A three-day post-conference tour is also being arranged, which will include three typical examples of the state-of-art hydraulic-machinery technologies in Japan. The tour will include the Kazunogawa pumped storage plant, which has 420 MW single-stage pump-turbines, designed for 779 m pump maximum-head, Okukiyotsu pumped storage plant with a 300 MW adjustable speed machine and Showa drainage center with an underground man-made river. Voith Siemens Hydro will contribute with paper presentations to state-of-the-art R&D topics (see page 42).

For further information

- http://iahrice.hyd.eng.hokudai.ac.jp

Conferences, seminars and symposia

Date/Event	Further information
October 10, 2006 **Hydro Power Seminar on Erosion** New Delhi, India	Held by Voith Siemens Hydro India **Paper presentations on the following topics:** **– hydro technology development** **– silt erosion mitigation** **– case studies and experience** **– quality assurance** For further information please contact Ranjan Chauhan: Ranjan.Chauhan@vs-hydro.com
October 12-14, 2006 **7th Power of India** Mumbai, India	**Voith Siemens Hydro paper presentations:** **Countermeasures to reduce hydro abrasive wear at hydro turbines parts** Dr. Kirsten Winkler, Voith Siemens Hydro, Germany **Case studies of large hydro projects: Three Gorges** Joachim Klein, Voith Siemens Hydro, Germany
October 17-21, 2006 **IAHR Symposium on Hydraulic Machinery** Yokohama, Japan	**Voith Siemens Hydro paper presentations:** **Using the potential of CFD for Pelton development** Reiner Mack, Dr. Wolfgang Rohne, Voith Siemens Hydro, Germany **Experiences with remote diagnosis support during commissioning of pumped storage power plants** Ulrich Seidel, Alexander Schechner, Martin Giese, Voith Siemens Hydro, Germany **Simulation of full load surge pressure and power oscillations at a hydraulic system with pump-turbine** Dr. Jiri Koutnik, Voith Siemens Hydro, Germany **Classification of vortex and cavitation phenomena and assessment of CFD prediction capabilities** Dr. Thomas Aschenbrenner, Armin Otto, Dr. Winfried Moser, Voith Siemens Hydro, Germany **Research of the jet interference of Pelton turbines** Tsuneaki Fujii, Dr. Tadashi Tsukamoto, Voith Siemens Hydro, Japan **Development of reversible bulb pump-turbine for refurbishment of the Lower Olt Project** Suzuki Ryoji, Manfred Göhringer, Voith Siemens Hydro, Germany http://iahrice.hyd.eng.hokudai.ac.jp/

Date/Event	Further information
October 27 - 29, 2006 **First International Conference on Hydro-power Technology & Key Equipment 2006** Beijing, China	The power industry of China has taken on a brand new look. Meanwhile, its hydro power construction is stepping into a new development age. In recognition, the First International Conference on Hydropower Technology & Key Equipment 2006 conference has been planned for this exciting venue. **Paper presentations by Voith Siemens Hydro**
November 22 - 24, 2006 **14th International Seminar on Hydropower Plants** University of Technology Vienna, Austria	**Voith Siemens Hydro paper presentations:** **Advantages of automated Finite Element Analyses (FEA) for electrical machine design** Dr. Stefan Lahres, Dr. Klaus Krüger, Voith Siemens Hydro, Germany **Design features of modern motor-generators for pumped storage power stations. The special features of Taian PSP (P.R. China) and Waldeck PSP (Germany)** Thomas Hildinger, Georges Moronis, Holger Henning, Voith Siemens Hydro, Germany and Ryochi Ujiie and Hirofumi Etoh, Voith Siemens Hydro, Japan **Integrated solutions for monitoring and diagnosis in hydro power plants** Dr. Eberhard Kopf, Dr. Klaus Krüger, Michael Rieg, Voith Siemens Hydro, Germany **Joint Control for hydro power project Bratsk, Russia** Martin Sallfert, Voith Siemens Hydro, Austria **Modernization of HPP Zakucac/Croatia, combined development by CFD and model testing** Thomas Maurer, Richard Donelson, John David LeBrun, Voith Siemens Hydro, Austria **Challenges in control technology of pumped storage stations** Gerhart Penninger, Friedrich Spitzer, Voith Siemens Hydro, Austria http://info.tuwien.ac.at/doujak/tagung2006/hp2/index2.htm

VOITH SIEMENS
HYDRO POWER GENERATION

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