HyPower

Voith Siemens Hydro Power Generation customer magazine

Electricity: the lifeblood of the modern world | Numerical analyses in electrical machines | New generator workshops

15

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Germany
Land of Ideas
Official Partner

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

Dear readers, dear partners,

Looking back at 2006, we can reflect on an exciting year for hydro within the global sustainable energy mix debate.

In this context, hydro power has passed many tests in various political frameworks again. Just in December, a Paris-based UNESCO workshop finally gathered the right audience to discuss in-depth the question of Greenhouse Gas Emissions from reservoirs. While many polemical debates and inconclusive non-scientific views were presented last year in which hydro power was the cause of CO_2 and CH_4 emissions and therefore contributing to global warming, we are now seeing much more sensible research guarded by a serious approach, involving appropriate political and scientific representation. Finally, the debate is returning to more essence and rationality.

The question of emissions from non-tropical reservoirs is now seen to be neglectable; tropical reservoirs must be monitored and measured on a wider basis and be mainly investigated for methane rather than carbon dioxide. Also, pre-impound conditions that create emissions after inundation must certainly be subtracted and cannot be attributed to hydro power as such.

Thanks to the formidable efforts through IHA and support of HEA, I am pleased to say that we have been successful and will not be summarily banned from Carbon Development Mechanisms or through IPCC guidelines as a whole industry with its products and services.

I still hold the opinion that hydro power has to play its role in the fuel mix of the future and still think that without hydro power the sustainable growth of economies and nations in a globalized world will not be possible. Hydro power's contribution will maintain sustainable development, energy, food, and water for all, reducing global poverty, and will help to reduce air pollution with its inevitable effects towards global warming.

Reading that, for example, a Brazilian utility "considers construction of coal fired plants, if it cannot find suitable hydro projects for investment" (press readings from Nov. 2006), occurs to me as bizarre as can be. This reconfirms the need to keep the flag flying for hydro power as a growing energy generation source, including innovative technologies for energy production from ocean water, such as wave or tidal. We will strongly support sustainable and well-managed hydro power projects, as defined by the IHA Sustainability Guidelines and their Assessment Protocol, which were developed and so well received in 2006.

As we go forward, let us show the world that we are an industry of consciousness and one that cares about the effects of its technology to the benefit of the world and its population.

If you have any comments or questions, please simply contact me at Hubert.Lienhard@vs-hydro.com

Electricity: the lifeblood of the modern world

Hong Kong skyline.

We have vast energy sources available at our fingertips. With each new day we make use of almost unimaginable forces in a form which has been tamed for domestic use – transformed into electrical power.

Electrical power is indeed the blood supply to the muscles of our industrial and informational societies. We take the ready availability of electricity for granted as a source of light, propulsion, heat and refrigeration and only seem to notice its importance if it is suddenly unavailable.

The world as we know it today would be impossible without electrical power. The lifeblood of civilization shoots through the arteries of modern society at almost the speed of light and has accelerated not only technological and scientific development but also our social life in a breathtaking way.

Our information and telecommunications systems, our transport systems and modern medicine all depend on electricity as an energy source. The fact that it can be applied anywhere and in any way and not necessarily at its point of production was the key to its global success.

Highway and bridge traffic at night, Shanghai, China.

Woman using early electric iron, 1908.

A water wheel at a mill in Gweek near Helston in Cornwall, UK, 1933.

In the 19th century the world was a darker and quieter place

In the first half of 19th century the world was a significantly darker and quieter place. Muscle power, water and wind were the most common sources of energy. The clatter of hooves could be heard in the street, water falling to drive a wooden wheel or the creaking timbers of a windmill with its sails turning. Wheels, levers, switches, rollers and pipes have been used for thousands of years to transmit power. What opened up the possibilities of machine production and started the Industrial Revolution was the use of energies which were created artificially to some extent by changing their physical characteristics and processing primary energy sources.

The steam engine was the first and most fundamental example of this but with electricity being used everywhere industrialization achieved a dynamism which had not been imagined before. From a historical point of view, electrification happened within a blink of an eye.

The breakthrough was provided by the International Electrical Engineering Exhibition held in German Frankfurt in 1891 which was supplied with power via an overland cable using the new three-phase technology from a hydroelectric plant some 175 kilometers away in Lauffen am Neckar (for more reading see also our essay starting page 50). A 300 horsepower water turbine was used to drive a 50 volt generator; the voltage was transformed to 14 kilovolt and transmitted via a rather thick 4 mm^2 copper cable.

Approximately 9,000 insulators were fastened to a cable which was suspended from wooden poles. Each of the poles had a warning sign showing a skull and crossbones. Power had been transmitted successfully and the trio of production, transmission and application of electricity was complete.

Electrical power had thus overcome a barrier which was a decisive obstacle for its predecessors: it did not have to be used at the place where it was produced. Power plants could produce electricity with steam turbines powered by fossil fuels, or drive a generator using water turbines and transmit power to outlying towns and factories.

Women filing index cards at government office, 1939, Washington, DC, USA.

Working in today's IT support.

Electricity changed cities and city life

In the beginning, electricity was still too expensive for the average household to replace oil lamps with electric lighting. But there was progress in the workplace. Factories and businesses could be illuminated individually and the transmission belts, which were often lethally dangerous and were used for mechanically transmitting the drive power to machinery, were replaced with small fixed electric motors.

Gradually, electricity first crept into the every day lives of factory workers, then into official buildings and public institutions and finally into the everyday lives of city dwellers, where it made a crucial difference – just as it changed the way cities looked, particularly in North America. Without the use of comparatively lightweight electric motors which made it possible to drive water pumps and elevator mechanisms, the city skylines would never have developed. Can you imagine New York without skyscrapers?

As the new possibilities were opened up by the use of electricity its transmission became a matter of fundamental significance for the infrastructure of industrialized countries and their economic development. Porcelain insulators, as used for telegraph and telephone cables, at first limited the maximum voltage for overland cables to about 40 kV. As insulator technology developed – the suspension insulator was invented in the USA in 1907 – it was possible to constantly increase the voltage: in 1912 the first 110 kV cable was put into operation, in 1929 the first 220 kV cable and in 1952 the first 380 kV cable. By the 1980s the maximum transmission voltage had risen to 1,200 kV.

Coal as the fuel of electrification

From the beginning, coal-fired power stations played an essential role in the production of electricity. Although the first power plants had an efficiency rating of 1 %, i. e. 12.3 kg of coal were needed to produce one kilowatt hour of electricity, improvements in combustion technology and materials and process technology meant that efficiency increased constantly. In the 1910s an efficiency of 5 % was achieved and by 1920 it was already 20 %. Coal was the most important energy source and there was a great deal of dependence on its availability. This unveiled the problems associated with an imbalanced energy mix. The First World War in Europe had given rise to supply bottlenecks and among other things had also brought about significant reductions in rail traffic, which to a great extent depended on coal-fired steam locomotives.

Movie playing at Whitestone Bridge drive-in, 1951, New York, USA.

Modern cinema complex at night, California, USA.

In consequence the rail network was electrified everywhere where power production was cheap and did not require expensive imports. In the Alpine countries water power made it possible to operate the railways with electricity, from 1918 onwards in Austria, Switzerland, Bavaria, northern Italy and the French Alpine region.

Electrification proceeded at breakneck speed during the twenties and thirties, although at different speeds and with different consequences for people's lives. This was particularly evident in North America where cities like Chicago or New York were bathed in gleaming electric light and many private households had electrical appliances to make everyday life easier whereas on the farms in rural America water was still being pumped by hand and homes were heated with wood burning stoves. Kerosene, oil lamps or candles provided meager light during the hours of darkness, laundry and ironing were the most arduous of tasks which took up an enormous amount of time. This did not change until the middle of the thirties when the Rural Electrification Administration brought electricity to millions of those living in rural areas. This required over 560,000 kilometers (350,000 miles) of electric cable.

Water power, nuclear energy, natural gas: the energy mix diversifies

At the same time numerous large-scale hydroelectric projects were started. The first generator on the Hoover Dam was put into operation and work on the Grand Coulee Dam commenced. The first six turbines there were put into operation in 1942. Up until the 1980's Grand Coulee was continuously expanded with additional turbine generator units. With an output of over 6,800 MW it is still the largest hydroelectric power plant in the United States. Later it was surpassed by even larger hydroelectric plants in Krasnoyarsk, Soviet Union, Itaipú, Brazil/Paraguay and, soon, Three Gorges, China.

Since 1951 when the first experimental reactor in the state of Idaho supplied electricity, nuclear power stations have gained in importance and today contribute about one fifth of the world's energy production – somewhat more than is provided by hydroelectric power throughout the world. In the second half of the twentieth century more and more power was also being produced by gas-fired power stations, but coal as the number one primary energy source remained intact. In spite of growing world electricity production this will not change in the foreseeable future.

Peru.

India and China hungry for electricity

The hunger for electricity is increasing all the time due to the huge demand of the developing economies of China and India. These two countries accounted for about 17 % of the world demand for energy in 2004. Their share in the growth of world demand for energy from 1994 to 2004 at about 40 % makes the dynamic growth of these countries very clear: these are the future markets for primary energy sources and they will also help to determine the world market prices for energy. According to estimates produced by the German Center for Technical Information (FIZ) in Karlsruhe, the world demand for power of about 15.7 million TWh in 2001 will more than double by 2030.

Grid stability is ever more important in the digital age

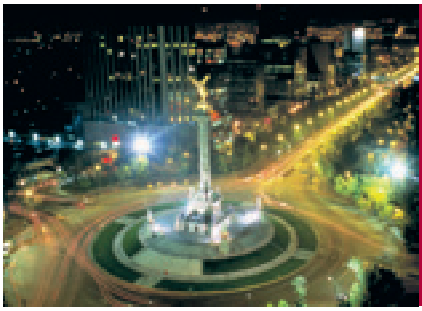
However, it is not only the demand for electricity which is growing. In our ever more digitized, networked and computerized world the requirements for reliability in power supply are increasing. Even the briefest of power interruptions of 1/60th of a second can have dramatic consequences for technology based on microprocessors. One of the greatest challenges of the 21st century is to guarantee necessary grid stability. A high level of reliability in power supplies as in western Europe can by no means be taken for granted. One of the main problems is that in order to guarantee grid stability and prevent voltages from rising and falling, precisely the same amount of electricity must be supplied to the grid at any given moment as is being consumed.
To be able to quantify the behavior of consumers within reasonable limits is just as important as the medium-term predictability of the development of per capita electricity demand. If, as a consequence of economic growth in the newly industrialized countries, millions of new consumers suddenly add their demand for electricity by turning on air conditioners, refrigerators and televisions to the grid, blackouts can soon follow.

Hydro power will have its share in a diversified energy mix

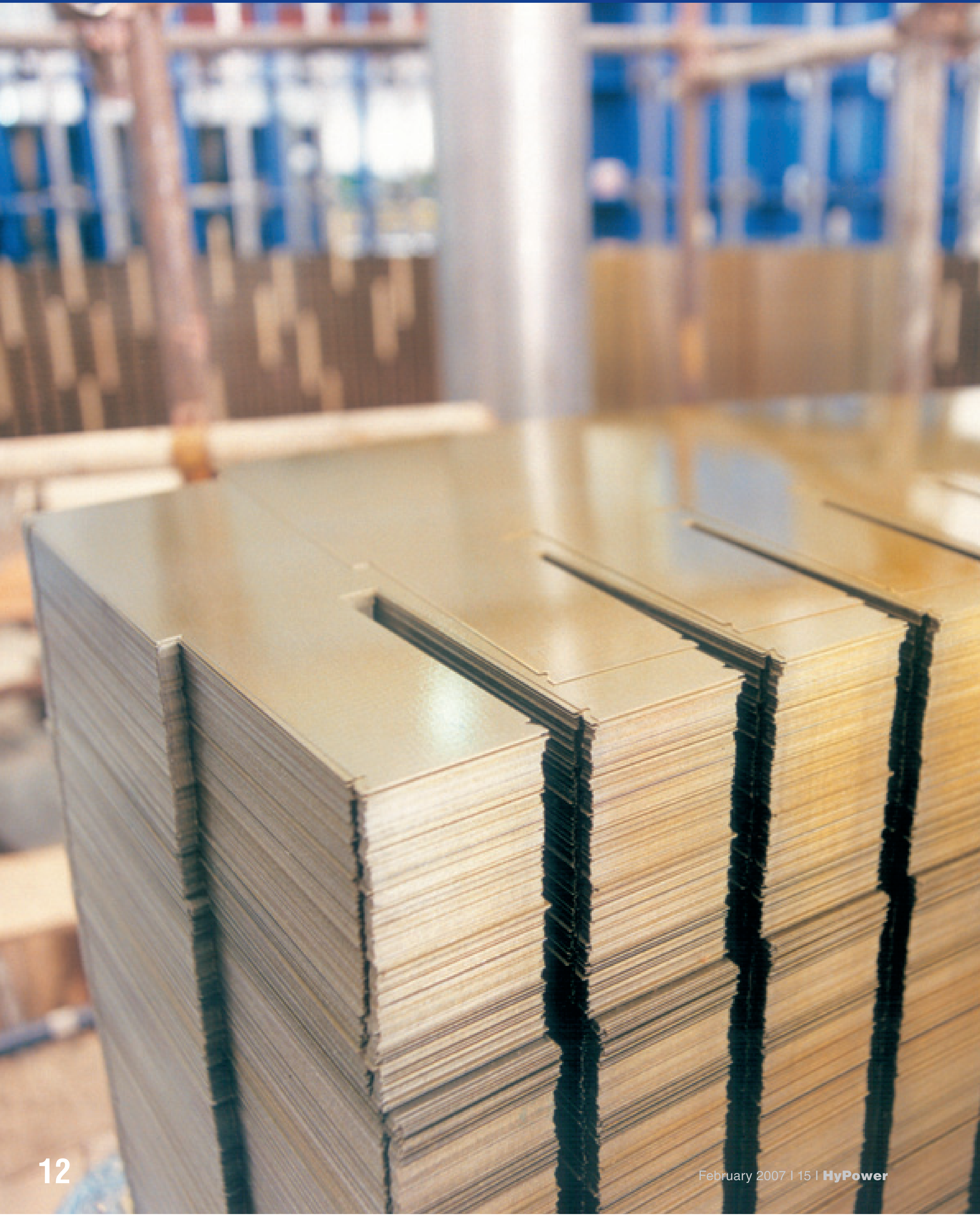
Industry and private households in India and China will cause a dramatic increase in energy demand. About three quarters of the electricity produced in China comes from coal-fired power stations; in India it is about 60 %. Both countries are becoming increasingly aware of the environmental consequences of this energy mix which has not yet been diversified to a great extent. In order to meet the rapidly increasing demand of their economies these countries with populations in the billions want to place a greater reliance on renewable energies, in particular by expanding hydroelectric power.

The governments of both countries clearly see the advantages of hydroelectricity as a domestic, non-polluting and secure form of energy that is virtually unsusceptible to price fluctuations. The Ministry of Power in India has launched an ambitious program called “Power for All”. Under this scheme, all individual households are to be connected to the power grid by 2012. It is intended to boost hydro power capacities to a desired share of 40 %. The Chinese government plans to increase the hydro power sector by 8 % annually. Efforts to significantly expand the generation of emission-free hydroelectricity are already under way. When fully commissioned in 2009, Three Gorges hydro power plant on the Yangtse River with its foreseen world record output of 18,200 MW, will supply more than 100 million people and the regional industry. Several other major hydroelectric projects are presently under construction, too. On the other hand, in Europe and North America where the economically feasible hydro power potential is already utilized to a high degree, pumped-storage stations with their unique quality to stabilize the grid will become more and more important.

Mexico city.



Internet cafe in Oruro, Bolivia.



Automated numerical analyses for the design of electrical machines

Demands on electrical machine design are becoming more and more diversified. The weighting of customer specification among requests for high efficiency, low investment costs, low maintenance costs, and tight schedules varies depending on national or local cost structure and philosophy. The design methods in the engineering departments of power plant suppliers offer a wide range of design utilities in order to consider the complex interactions in each stage of the design process with an appropriate degree of detailing.

A comparison with the analysis of the hydraulic machine is helpful to understand the special challenge and the advantages of numerical analyses of electrical machines for hydro power plants.

Automation of the numerical analyses is only feasible if the reliability of the analysis is proven, and the automation is only efficient if the analysis is frequently applied.

Here, the term Numerical Analysis is used as the super-ordinate term for analyses based on the Finite Element Method (FEM), Finite Difference Method (FDM), Finite Integration Method (FIM) and Computational Fluid Dynamics (CFD) based on Finite Volumes.

Classic alternatives to numerical analyses are analytical methods, which can be divided into

- close-form analytical solutions of partial differential equations and
- analytic expressions describing isolated physical effects based on
  - first principles together with heuristic corrections or on
  - empiric parameter fitting of heuristic expressions.

Numerical analyses of electrical machines still face challenges

Automated numerical analyses in electrical machines are relatively newly used, while they are a very helpful software tool for years in the hydraulic layout of turbines by means of automated Computational Fluid Dynamics (CFD) analyses.

Coupled with the structural analyses by Finite Element programs, a simultaneous hydraulic and mechanical layout of the hydraulic components is created. The main design criteria for the hydraulic layout are fed by the results of these analyses.

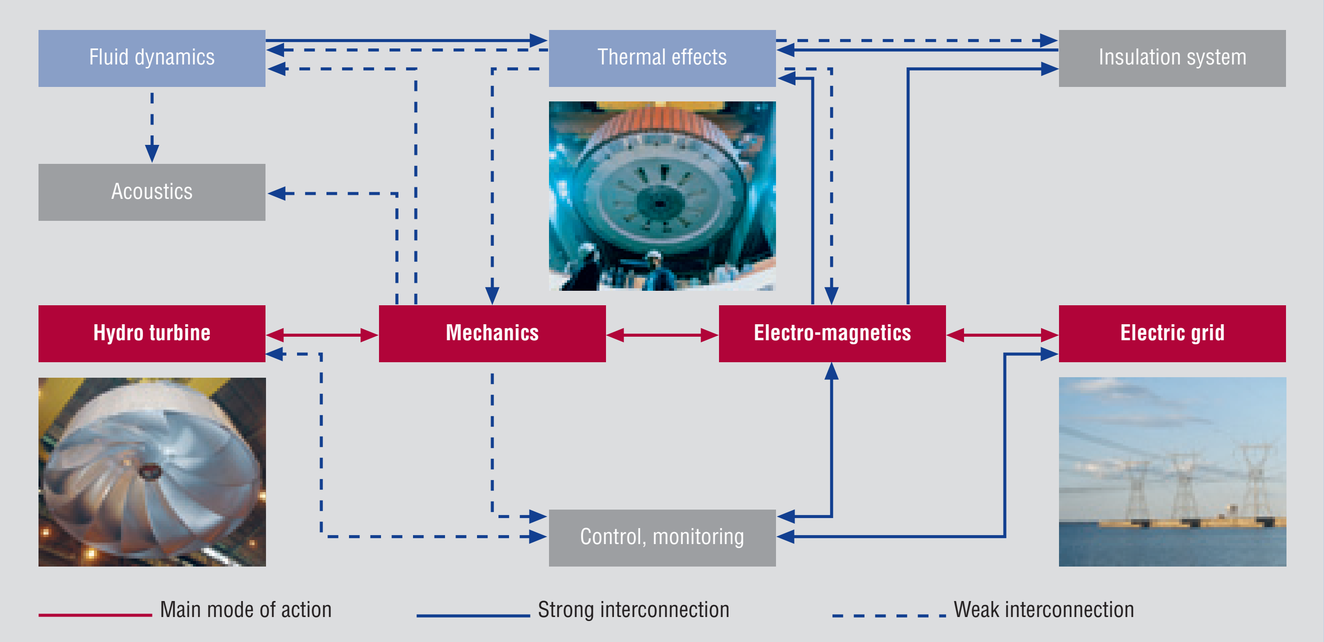


Figure 1: Physical domains related to generator and couplings between them.

Numerical analyses of complete machines are still under development in electric machines for hydro power plants. Combinations of analytic approaches and numerical techniques are typically used in electromagnetic analyses.

The reason for the continuing use of analytical analyses in electrical machine design is that numerical analyses of electrical machines still have some challenges that inhibit the numerical computation of all relevant effects in the electrical machine.

Numerical analyses like FEM or CFD of electrical machines face several challenges that need to be solved in order to automate the analyses for the design process. The various physical domains that dominate the layout of the electric machine are: electromagnetics, high voltage effects, mechanics, thermal effects, fluid dynamics, acoustics, and coupling to the electric grid and hydraulic system.

Some domains show strong couplings between each other (solid arrows). Other show weak couplings (dashed arrows).

Dealing with non visible quantities

Finite Element programs for electromagnetics still have weaknesses, e. g. in considering eddy currents, moving components, and iron loss mechanisms. Due to the electromagnetic skin effect the machine consists of very small components like steel sheets and stranded conductors. But they interact over long distances. This scale problem requires computers with vast memory and correspondingly long computation times.

Full 3D transient analysis of all electromagnetic effects in the electric machine is not (yet) feasible. Therefore, appropriate sub-models and combinations with analytical calculations have to be chosen.

In electromagnetic analyses non-visible quantities like magnetic vector potentials, vector fields of magnetic field strength, magnetization and current density must be dealt with. Thus, post-processing the results is not as obvious as for example in mechanical analyses.

Complex challenges of heterogeneous and jagged structures

Modeling of heterogeneous structures such as the rotor rim, the stator core or the stator winding affords quite detailed models that cannot be solved for the complete machine. Thus, appropriate methods to derive homogenized simulation models have to be applied. CFD of the cooling and ventilation of the machine has to deal with jagged structures and consequently quite complex flow and heat transfer situations.

Harder than it seems: understanding the results

If you derive analytical expressions for a certain problem, you automatically try to understand the physics behind the problem and divide the mixture of effects into distinct effects. If you just apply numerical analyses, you do not need to understand the separate effects. The user nonetheless needs to understand what happens to recognize systematic dependencies. It is possible to bring the two approaches numerical analyses and analytical solutions together by analyzing parameter studies on numerical analyses using the old knowledge of electrical machine calculation. This provides a basis for understanding even more complicated dependencies than was possible with only analytical approaches.

Electrical machine design never starts with automated numerical analyses

During the design of an electrical machine the engineers can use a wide range of software tools to make the design according to the external and internal requirements. In order to get appropriate design suggestions and decisions in time, the design engineer has to balance calculation time, accuracy, detailing, and flexibility. In early stages of the project, the detailing cannot be very high, as not many details have yet been defined. Flexibility in the geometry and materials is especially important for modernization projects or unusual designs.

Automated numerical analyses are applied more and more in the second half of the basic engineering process, where accurate calculation of machine parameters and characteristics, losses, temperatures, forces and stresses is required. In order to provide fast and accurate calculations, the automated numerical analyses are used to derive analytical expressions to describe important dependencies in the electrical machine. Design guidelines are derived from these dependencies to provide the design engineer with straightforward design rules.

Automatic numerical analysis steps

1. Preliminary electromagnetic layout with software tools based on analytic relations and optimization environment.
2. Transfer of preliminary layout to user interface for detail configuration of geometry, load cases, post processing quantities, and finite element analysis setup.
3. Automatic generation and parameterization of CAD model and export of geometry to finite element tool.
4. Automatic analysis of the specified load cases and post-processing quantities. This step includes meshing, applying boundary conditions and various load cases, solving, and post-processing. This step affords CPU time and commercial software licenses.
5. Multi-physics analyses additionally afford special consideration of the coupling of the physical domains electromagnetics (voltages, current densities, currents, eddy current densities, magnetic field quantities, flux lines, saturation levels, forces), temperature, mechanics (displacements, forces, stresses).

Automated numerical analyses speed up modeling

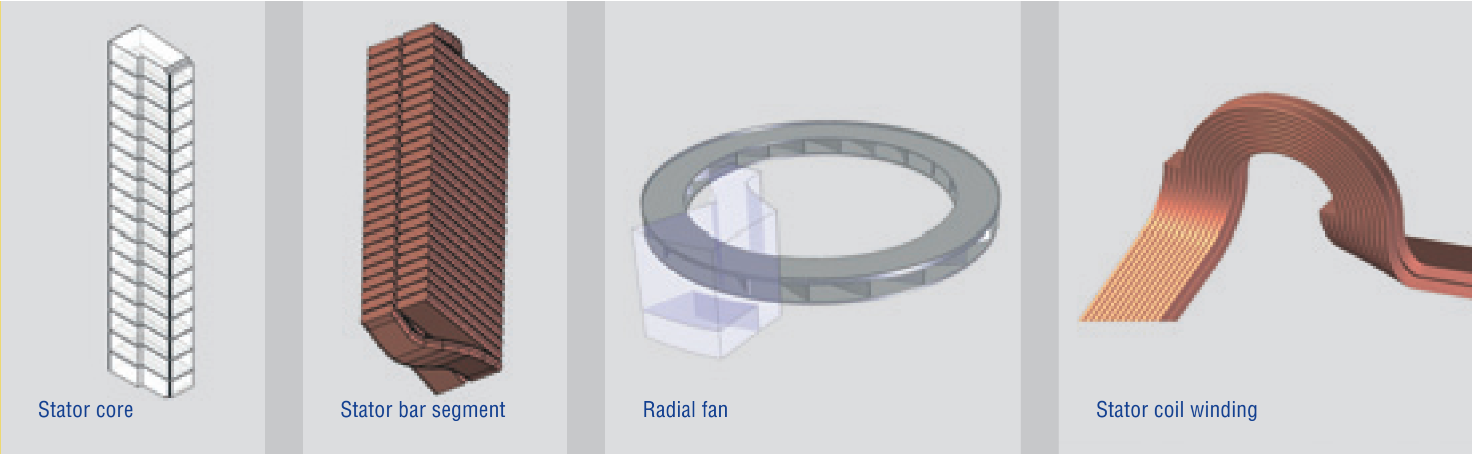
In many of the electromagnetic problems on electrical machines, which great engineers worked on with analytical approaches for the last 100 years, the numerical analysis provides accurate results for less idealizing assumptions. Of course, the large number of problems solved with analytical methods and verified by a huge number of measurements is used to verify the results of numerical analyses by calculating the ideal set-up with each numerical analysis. In order to carry out these comparisons, you need to have the modeling and the numerical analysis automated, and the detailing must be appropriate. Consequently, the tools to prove superiority with respect to precision of the numerical analyses over analytic approaches are available. Of course, computational effort is still an issue, but automated instead of interactive modeling and post-processing accelerates the analysis process significantly and releases the engineer from repeated similar modeling work.

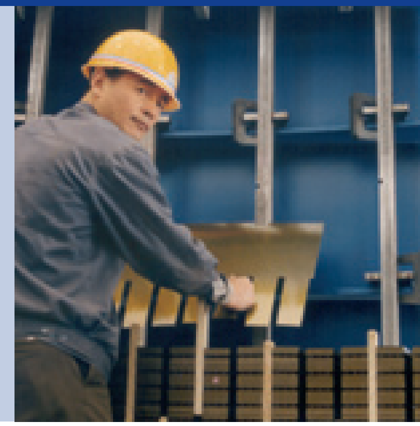
Advantages for the customer and the supplier

The standardized and frequent application of numerical analyses during the design of electrical machines offers advantages for suppliers and customers of hydro power plants. The ability of numerical analyses to calculate with smaller uncertainty allows more precise optimization for the customer requirements. Thus, during the machine design process, fewer safeguards for compensating possible statistical influences are needed. This opens opportunities for more efficient machines or many other design criteria.

As numerical analyses have a broader application range than empirically corrected analytic methods, they also offer a high reliability for design variants that are more innovative than the standard and experience-proven designs.

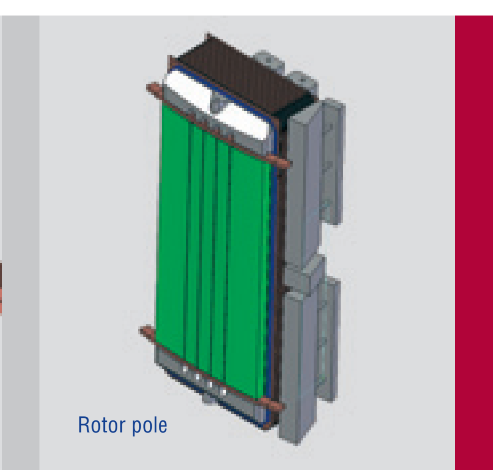
Figure 4: Parametric CAD models for automated numerical analyses.





This advantage is more relevant for R&D than for automated analyses during project execution, as the results of such investigations on new design variants have to be proven by additional tests before they are applied in the daily engineering process.

In the modernization business, you are often faced with designs from other manufacturers that differ from the own company standards and need to be understood and verified before changes in the machine are initiated. The company proprietary analytical methods might not be applicable for these foreign designs.


Rotor pole

In this case, slight adjustments of the standardized automated numerical analysis according to the design features of the existing machine also allow quite a fast application of the automated analyses for these machines.

For machines with high utilization, it is important to know the spatial distribution of quantities like temperature or magnetic induction, as peak values limit utilization.

The automated numerical analysis offers the possibility of investigating this detail information for a large number of machines.

Automation of numerical analyses: a good investment

In many cases it is efficient to invest in the development of automated numerical analysis tools, as they enable design engineers of electrical machines to optimize the machine with low effort more precisely with respect to customer defined criteria, internal processes, external boundary conditions (like raw material cost) and the level of detailing of the used calculation.

Numerical analyses in electrical machines will still be focused on a wide range of sub-models over the next years, as the numerical analysis of all physical effects in one simulation model of the complete electrical machine still faces too many challenges. Nevertheless, the implementation of several automated numerical analyses of sub-models shows the wide application range of this method for the design of leading-edge electrical machines for hydro power units.

The knowledge of how to build a machine in order to optimize it still has a strong source in experience, analytical descriptions and engineering intuition, but it is significantly enriched by the intelligent analysis of representative parameter studies on automated numerical analyses.

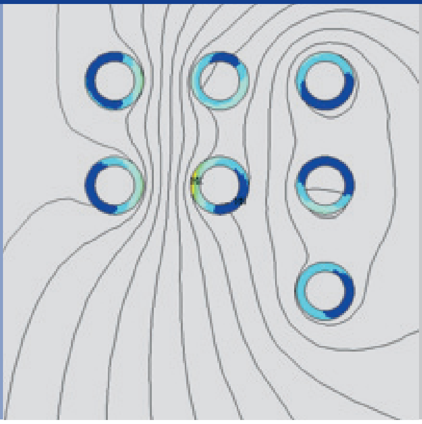


Figure 5: Power loss density in circuit rings and flux lines in surrounding air.

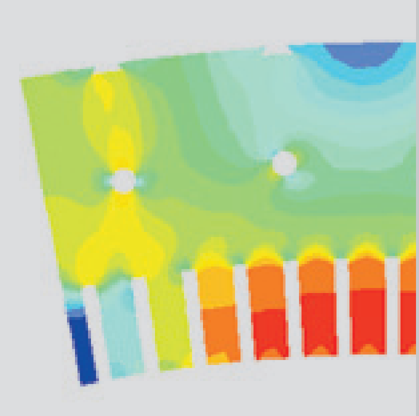


Figure 6: Magnetic induction in the stator core lamination.

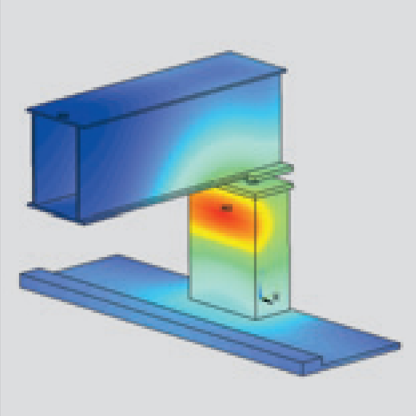


Figure 7: Temperature of surrounding steel components (here: stator frame neck and bracket) due to eddy current heating.

Examples of numerical analyses in electrical machines

In order to perform numerical analyses of generator components parametrically, the preparation of parametric CAD models is an important step for the automation of the analysis process. The detailing of the CAD models used for machine design usually has to be reduced in order to perform efficient numerical analyses. Periodic segments are often sufficient.

Figures 5 to 10 show examples of more or less automated numerical analyses of components of electrical machines.

Figure 5 shows the results of an electromagnetic 2D-axis-symmetric linear harmonic finite element analysis, which investigates the current density distribution and the heating of the tubular circuit ring leads of the three phases at one location of the circumference.

As the finite element analysis can consider the interaction of the current distribution of all circuit ring leads and the surrounding magnetic steel components for arbitrary cross sections, it is superior to analytical solutions that always have to deal with idealized geometries. It takes less than one minute for this automated analysis to consider several different cross sections and the calculation of total circuit ring losses and maximum temperature.

Figure 6 shows the results of an electromagnetic 2D planar nonlinear time transient finite element analysis, which is used to investigate the influence of design details on the magnetic circuit for arbitrary load cases. Analytical methods such as magnetic equivalent circuit diagrams and conformal mapping are only able to consider the inhomogeneous saturation of the active iron in a restricted manner.

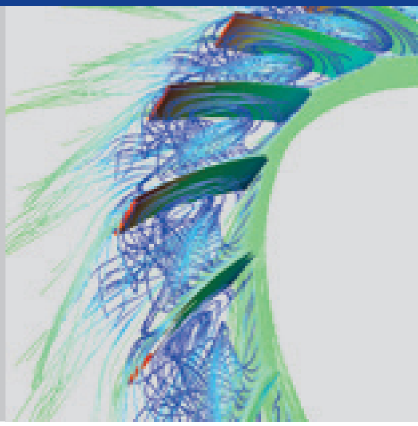


Figure 8: CFD analysis of a radial fan.

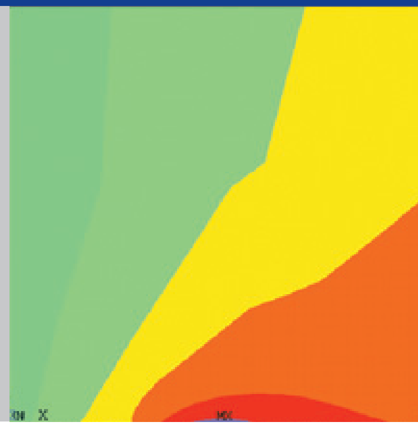


Figure 9: Electric potential at a semi-conductive corona protection of the stator end winding.

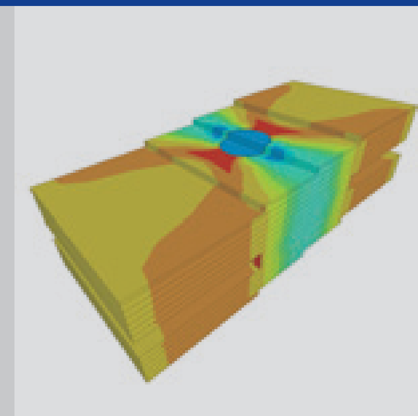


Figure 10: Nonlinear stress-strain analysis of a periodic segment of a rotor rim for homogenized FE analysis.

Figure 7 shows the results of an electromagnetic and thermal 3D nonlinear harmonic finite element analysis of the eddy current heating of the steel components surrounding the circuit ring leads and the terminal leads. This automated analysis considers the saturation dependent skin effect of the eddy currents in the steel components and is used to determine whether or not a copper shielding for the steel components is recommended.

Figure 8 shows the results of a 3D fluid dynamics analysis of a radial fan for the cooling ventilation of the electrical machine. The automated CFD analysis derives the pressure-flow characteristics of the fan for various geometry variants.

Figure 9 shows the results of an electrodynamic 2D nonlinear time transient finite element analysis of the capacitive currents and the electric field strength in and near the semi-conductive corona protection of the insulation system of the stator end winding.

Figure 10 shows the results of a very detailed mechanical 3D nonlinear finite element load step analysis of a periodic segment of a rotor rim. The detailed model considers elastic plastic material properties, friction and contact between sheets and bolts. The results are used to automatically derive a homogenized material law, which is later applied in a nonlinear mechanical analysis of the complete rotor to investigate and optimize the behavior of the rotor during extreme load sequences.

Further examples

The following is a typical list of further electromagnetic investigations, where automation of numerical analyses brings significant advantages:

- Distributed iron loss calculation in the stator core
- Detailed geometry modeling of the critical components and regions
  - clamping bolts (stator and rotor)
  - fixation systems (pole and stator core)
  - stator winding and slot region
  - damper winding and pole shoes
  - magnetically high saturated regions
- Damper currents in special load cases
- Influence of grids with many frequency converters (e. g. railway grid with power feedback) or other strong sources of harmonics
- Calculation of harmonics of magnetic field, electric current, and voltage, and calculation of their influence on losses, forces and temperatures
- Load-dependent leakage flux components

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Huang Dinan, President of SEC, Shanghai Electric Corporation (left) and Dr. Hubert Lienhard, CEO of Voith Siemens Hydro, jointly unveil the corner stone of the new generator factory.

Aage Dalsjoe, President Voith Siemens Hydro Shanghai and host of the ceremony during his opening speech.

Yang Qing, Deputy General Manager from China Three Gorges Project Corporation (CTGPC).

Groundbreaking ceremony for Shanghai generator factory

With a solemn groundbreaking ceremony, rounded off with fireworks and corner stone unveiling, Voith Siemens Hydro recently celebrated the start of construction of its new generator factory in Shanghai.

Joining Voith Siemens Hydro's Brazilian, North American, and Swedish facilities for generator manufacturing expertise, the Shanghai location will now develop into a full-fledged generator manufacturing workshop.

With this new Chinese electrical facility, that is to start operation on an area of 3,200 square meters by the end of 2007, Voith Siemens Hydro will tighten its established global network for generator manufacturing in close proximity to customers in all important hydro power markets.

The company will invest approximately seven million Euros in this new generator manufacturing facility, which will employ approximately 80 people when it opens.

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New German workshop for generator rehabilitation and service

The Heidenheim location of Voith Siemens Hydro has been the "cradle" of Voith's hydro activities since its first turbine delivery in 1870. It has ever since been a location with first-class manufacturing expertise and services.

Developing from a completely Germany-based workshop to a global enterprise over 140 years, Voith Siemens Hydro's manufacturing structures and locations have changed and expanded into markets where hydro power today is a major resource. Still, the Heidenheim workshop to-date works on the whole range of equipment from bearings to complete runners for its mainly German and European customers. Modernization and rehabilitation constitute the main business with these customers. But also business for new plants has recently taken up pace in and around Germany, Europe, and other markets of the German operating unit.

What is new: in order to better serve electrical rehabilitation in these markets, Voith Siemens Hydro Kraftwerkstechnik in Heidenheim has started to implement completely new work areas for the rehabilitation of generator stators and rotors.

Stacking of new stator cores, assembly of stator windings and re-insulation of poles will be feasible beginning in spring 2007. Projects are already booked from Kenya, Albania, Germany, Switzerland and Portugal. The workshop will be equipped with state-of-the-art machines and tools.

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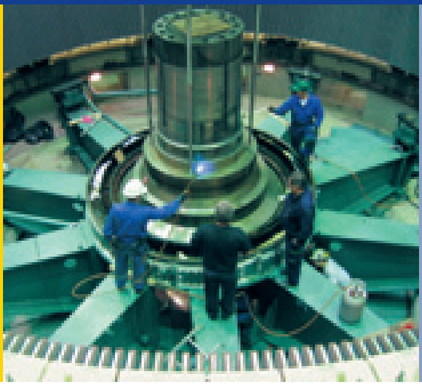
Outside view of Voith Siemens Hydro Kraftwerkstechnik building, Heidenheim.

VG Power
A Voith and Siemens Company



Stornorrfors generator rehabilitation through VG Power.

VG Power office building in Västerås.

Voith Siemens Hydro is majority shareholder of Swedish VG Power AB

Voith Siemens Hydro has acquired the majority of shares of VG Power AB in September of 2006. The Swedish hydro specialist focuses on modernization, rehabilitation, upgrading, as well as service and repair of electrical equipment for existing hydro power plants, but also on design and manufacture of new generators for hydro power plants.

Voith Siemens Hydro now also has a location in Sweden: Västerås, and is thus strengthening its presence in the Scandinavian market. The strong focus of VG Power on generator rehabilitation increases the expertise in this field. For VG Power, joining forces with Voith will open up an enormous growth potential in the worldwide hydro market. The strategic goals of the two companies complement each other perfectly. Last summer, Voith Siemens Hydro already acquired a 51 % majority in VG Power.

The business of this young company, founded in 2002, and employing 50 people, is primarily based on the rehabilitation and modernization of generators for hydro power stations. But service and maintenance as well as the production of new generators for hydro power plants in Scandinavia and beyond also contribute to the success of VG Power.

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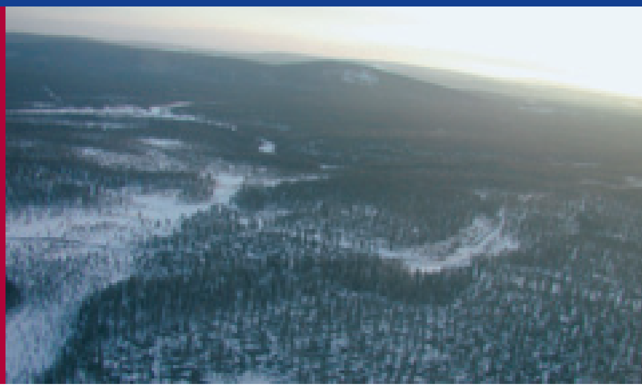

Ligga hydro unit refurbishment awarded by Vattenfall

Voith Siemens Hydro received a contract from Vattenfall, Sweden, for a major turbine refurbishment for Ligga hydro power station's unit 3, with the option of overhauling unit 2, as well.

In a signing ceremony at the headquarters of Vattenfall Vattenkraft AB in Luleå, the two companies celebrated a new era of collaboration, as this is the first time that Vattenfall AB contracted Voith Siemens Hydro as a supplier for turbine equipment.

Ligga hydro power station is located around 20 kilometers north of Jokkmokk in Lapland. Ligga's unit 3 was installed in 1982, and was, at that time, the most powerful Kaplan turbine in the world, with a capacity of 189 MW. Today, this unit is still the most powerful Kaplan unit installed in Sweden.

The new design of the refurbished runner from Voith Siemens Hydro will be model-tested at the Vattenfall laboratory in Älvkarleby in spring 2007.

Voith Siemens Hydro's upgrade of the turbine will be undertaken at the site in a consortium with Vattenfall Service Nord, Sweden. It includes installation of a new oilless hub runner with improved performance and a new high-pressure oil system, – both measures to further strengthen Vattenfall Vattenkraft AB's position as an industry leader in the generation of environmentally friendly energy.

Having won the award for the modernization of Ligga is of great importance to Voith Siemens Hydro, as the company has just emphasized its strong interest in the nordic market by its recent acquisition of a majority share of VG Power AB in Sweden, a well-established company in the field of major generator rehabilitation.

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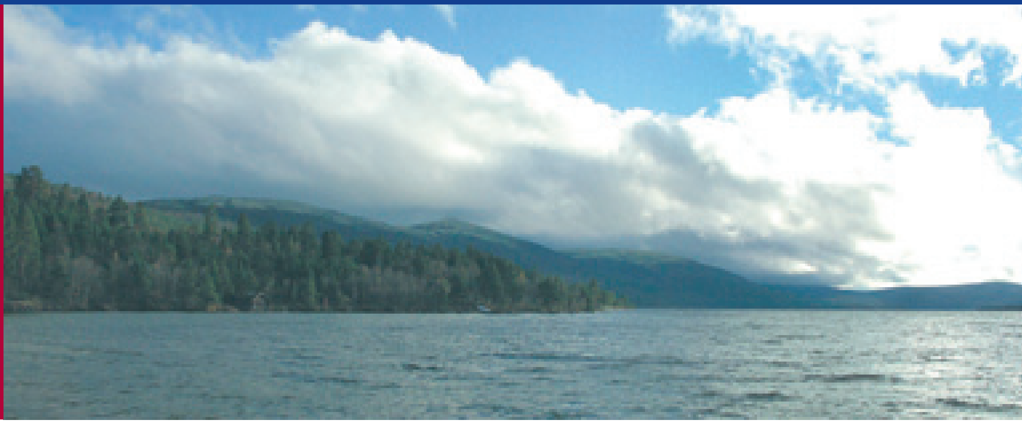
Factory acceptance test team with the customer of Savalen.



Lake Savalen.

First Thyricon™ 600 system installed at Norway's Savalen

Savalen hydro power station, operated by the Norwegian energy supplier Eidsiva, has recently been connected to the grid, equipped with the first Voith Siemens Hydro Thyricon 600 unit.

It supplies up to 4,000 ampere excitation current and can be used even for particularly powerful generators with capacities of over 700 MW. After Thyricon 400 and 500, Voith Siemens Hydro now has another important milestone project in this performance class. The Thyricon 600 system for Savalen was developed by the Voith Siemens Hydro units in Trondheim and São Paulo, and produced in Trondheim. "Thyricon" as a product name is now a registered trademark in Europe in the meantime.

The Thyricon family is a modular excitation system that can be customized to individual requirements over a wide application range.
All hydro power generators and motors from 0.5 to 800 MW can be provided with an optimized solution. The excitation system is equipped with digital voltage regulators that allow rapid grid response. A power system stabilizer, minimizing power oscillations, can also be added.

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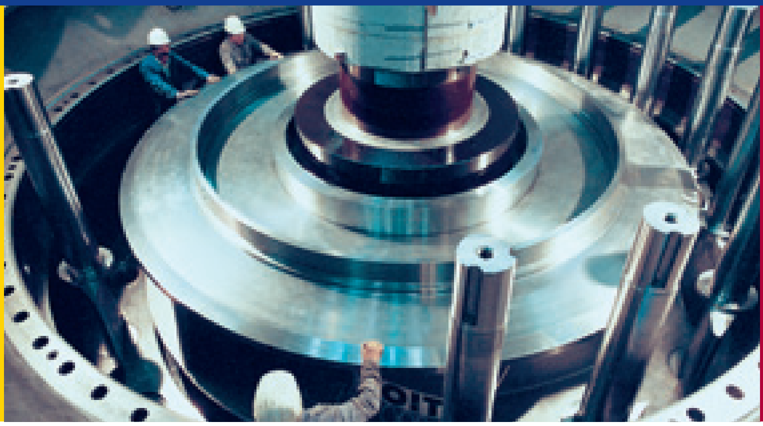

Herdecke pump-turbine, Germany.

HyCon™ 400 control system for Germany's 150 MW Herdecke pumped storage plant

RWE Power AG has awarded Voith Siemens Hydro with the refurbishment of the 150 MW Koepchenwerk pumped storage plant near Herdecke, Germany. The plant was built new 1985 to 1989 as the successor of the old Koepchenwerk commissioned in 1930 as one of the first pumped storage plants of its time, decommissioned in 1994.

The scope of supply is comprised of a process control system and a HyCon 400 digital turbine governor. When the project is completed, other plants of the upper and lower Ruhr will be operated from the new central control room at Koepchenwerk, too.

HyCon 400 is based on a standard Siemens automation system optimized with hydro specific function modules developed by Voith Siemens Hydro. The main features include a local operator panel which is independent from the central operator system and the centralized engineering station for parameterization of the different automation levels of the control configuration. A redundant automation system guarantees high availability.

The newly installed flexible control system will improve and optimize process control during daily operation. To save costs an existing pager system and video observation will be integrated into the new solution. Voith Siemens Hydro will also supply a complete set of new upgraded rotor poles and refurbish the intermediate shaft.

The new Koepchenwerk is located at the north bank of the Ruhr River where the impoundment is located, forming Lake Hengstey. The upper reservoir of the pumped storage hydro power station has a capacity of nearly 1.6 million cubic meters. This represents a stored energy capacity of 590 MWh, i. e. a full reservoir allows the power plant to operate four hours at full-load.

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St. Pölten strong pillar in terms of generators

Traditionally more geared toward the production of hydro-mechanical components, the Austrian facility of Voith Siemens Hydro has recently also become an important center of expertise in the area of generator technology.

Akköprü power house view.

The operating unit is currently involved in numerous new projects for 14 generators made for six projects in two countries in South-eastern Europe and in the Middle East. Also, an extraordinary "back-log" of 164 governors contracted from 47 hydro power plants for new turbines or turbine and governor modernizations and stand-alone projects are currently in production.

At present, the St. Pölten location is working on four projects in Turkey, supplying and installing a total of five generators with a total output of approximately 233 MVA for the new construction of the Akköy and Uluabat hydroelectric power plants. Moreover, an additional contract is under way for two generators of 46 MVA each for the Akocak project. Also, in February 2006, DSI, the Turkish state-owned power company, awarded St. Pölten a contract to equip the Akköprü hydroelectric project.

The scope of delivery is comprised of two 65 MVA generators and two 59.3 MW vertical Francis turbines, including turbine governors, automation technology, transformers, and transformer stations.

The Akköprü power plant is scheduled to be connected to the grid in 2008. With a power production of 343 GWh annually, it will contribute a large portion of Turkey's energy generation from hydro power.
Due to a heavily growing energy demand, Turkey has started numerous hydro power projects. By 2023, the country wants to increase its power production through hydro power to 433,000 GWh.

St. Pölten is also involved in two power plant projects in Iran: It currently is supplying a new 81.5 MVA generator for Marun II and looks forward to an additional contract for four 300 MVA motor-generators in cooperation with the Brazilian and Japanese operating units of Voith Siemens Hydro.

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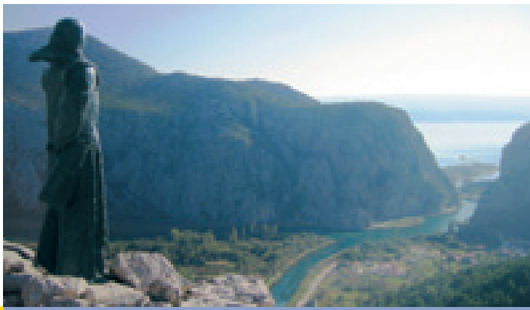
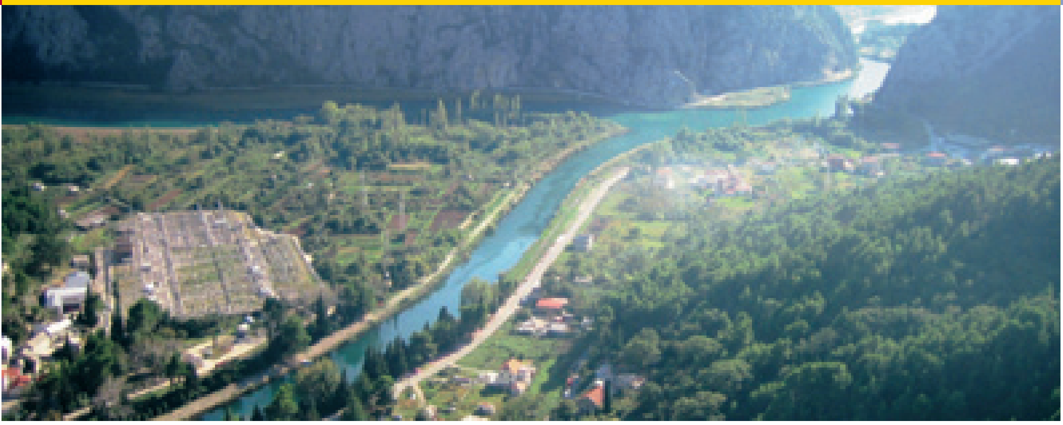
Modernization in Zakucac

Winning competitive model tests, Voith Siemens Hydro was awarded the contract for modernizing and upgrading four vertical Francis turbines and spherical valves for the Zakucac hydro power station. After re-commissioning, the most important hydro power plant in Croatia will generate 600 MW of clean, renewable energy.





Zakucac had originally been built in two stages. The first stage is comprised of units 1 and 2, 110 MW turbine generators, supplied by Voith in 1961. About 19 years later the second stage was erected including an additional headrace tunnel with surge chamber and penstocks, feeding two new units with 270 MW of total capacity.

All electromechanical equipment is installed in an underground cavern. The tailrace system directs the water through a 350 m long tunnel out of the power house back to the Cetina River, just 1700 m upstream of its estuary to the Adriatic Sea.

With the specific role and importance of the power plant in the Croatian electric power system in mind – Zakucac is Croatia's largest hydro power plant – the operator's expectations for the refurbishment were high. Intensive investigation and hydraulic development, both in CFD analyses and conventional model testing, was required. The main focus of the upgrade was increased power from 110 to 150 MW while keeping the already excellent cavitation performance of the existing units.

Final evaluation of the offers was done by considering the results of the competitive model tests in an independent laboratory between the two highest evaluated bidders. Voith Siemens Hydro's model showed the best performance, the measured mean weighted efficiency was even slightly higher than the stated guarantees. With the award of the contract for Zakucac, Voith Siemens Hydro continues its long and successful relationships in Croatia.

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Modernization of Tiszalök plant in Hungarian national park

With the modernization of the Tiszalök hydroelectric plant, Voith Siemens Hydro further expands its activities in Hungary. The renovation of the mechanical and technical components of the 50-year-old plant on the Tisza River will begin in November 2007.

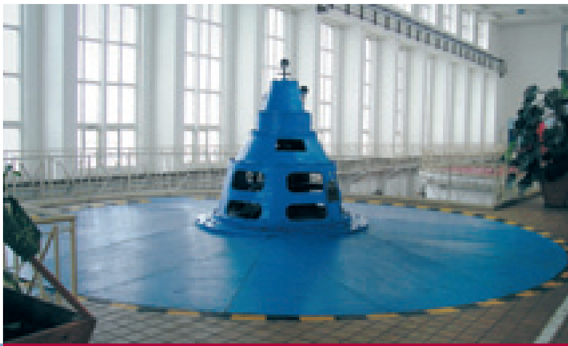
This new contract was awarded by the operator, Tiszaviz Vizeroemue KFT, Tiszalök, for whom Voith Siemens Hydro, in cooperation with Siemens RT Budapest, had recently updated the Kisköre power plant to state-of-the-art-technology from 2002 to 2006

Tiszalök currently operates with three vertical 4.5 MW Kaplan turbines, which will be rehabilitated and partially renewed in the coming years. The contract also includes the installation of new Kaplan runners, discharge rings, wicket gates with gate accessories, thrust bearing parts with instruments, new turbine governors, automation and control equipment, including static excitation systems and generator parts.

The modernization of the units will take place at yearly intervals; completion of all work is scheduled for August 2010.

Not only installed capacity, but also power production will be increased by more than 10 percent through this modernization, resulting in an annual output of 54.5 GWh. Thus, the energy obtained from the Tisza River will be increased without affecting the environment through construction – an important contribution to protection of the landscape in the area that is part of Hungary’s largest national park and UNESCO World Heritage Site Hortobágy.

The Tiszalök power plant, built in the 1950’s, is considered a technological monument to this day. As the first dam of Lake Tisza does not only provide energy but also irrigation. In the 1970’s, a second dam was built for the Kisköre power plant creating a new man-made lake with a surface area of approximately 127 square kilometers; it is one of Hungary‘s largest inland waters.



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A special field service challenge in Afghanistan

In 2003 and 2004, the US and German operating units of Voith Siemens Hydro were awarded the Kajakaj, Sarobi and Mahipar modernization projects in Afghanistan. For the three power plants, the supply was shared between US and German operating units while all field service activities were handled from Voith Siemens Hydro in Germany.

The difficulty in recruiting experts available to work in crisis areas in conjunction with the breadth of the qualifications required to cope with the scope of supply, were just some of the problems to be solved.

The safety and security of the people working at site was Voith Siemens Hydro's main concern. In this regard, security plans covering everything from touch-down at Kabul airport to the camps and to the power stations, were deeply studied and regularly checked. The security infrastructure was based on an efficient and reliable satellite communication system.

The overlapping of the two projects made it almost impossible to have the same team working on both of them.

The logistics of Kajakaj, located near Kandahar, a region protected by U.S. troups, made it necessary for people to live within a camp attached to the power station and protected by 180 soldiers. People landing in Kabul were transferred by helicopter to the site. The five hour journey was less than comfortable. Each pilot had its own safety strategy: one was flying close to the ground, the other at an elevation of 3,000 feet.

The two power plants of Sarobi and Mahipar are located near Kabul on the main road to Jalalabad. The large portion of machining existing components required the installation of a manufacturing facility in Kabul. Therefore, the Sarobi and Mahipar site manager was in charge of three working sites.

In addition to normal duty, an important task for the site managers was to keep morale high and maintaining a relationship with the local security forces.

The modernization of the turbine and the need to assess, repair and recommission the existing mechanical governor, generator, excitation and auxiliary systems, which were completely obsolete, required the mobilization of more than 15 technicians in Kajakaj coming from various countries.

The Sarobi and Mahipar team was formed by more than 20 experts with international experience from other Voith Siemens Hydro projects worldwide. The scope included the rehabilitation of the turbine and generators, new governors, excitation, automation and protection systems, switchyard equipment, and more.

Despite the challenges and the extreme weather conditions during the winter of 2004-05, the most severe in the last 30 years, the Kajakaj unit was put into commercial operation 20 days ahead of schedule.

The first unit of Sarobi had been commissioned on time in November 2006, despite the delayed starting date and multiple interruptions. Voith Siemens Hydro staff will remain one more year to complete the remaining three units. Upon their completion and their commissioning, the three power plants will constitute 20 % to Afghanistan's overall power generation capacity and have a share of more than one third in the country's hydro capacity.

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View inside the powerhouse.

Visitor delegation at the site.

Omkareshwar construction site.

Indian Omkareshwar progressing well

Following the installation of the first units for the new Omkareshwar hydroelectric power plant in India, Voith Siemens Hydro is poised to provide more positive interim results. All work was completed within the specified limits and some future work could even be completed earlier than planned.

The power plant on the Narmada river near the city of Madhya Pradesh is to be connected to the grid at the end of 2007 and will, with a total installed capacity of 520 MW, significantly contribute to the subcontinent's growing energy demand.

Voith Siemens Hydro as the turnkey contractor, entrusted in 2003 with off- and on-shore supplies of electro-mechanical equipment as well as all inland services such as site storage, erection, testing, and commissioning of all electro-mechanical components, supplies eight 65 MW power units, comprising Francis turbines and the relating generators.

The project must be completed in just under 48 months – a task that places high demands on all involved in terms of technology and logistics.

The collaboration with new partners as well as complex logistics processes during the component's transportation from Europe, Brazil and China to India presented new challenges for the project team which were successfully mastered. The last unit will be turned over to the customer in October 2007.

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Moyopampa, Peru.

Salto Pilão and Peruvian Moyopampa stand out among São Paulo projects

The first steps have been taken towards the implementation of a new Brazilian hydro power plant: the Salto Pilão hydroelectric power plant, to be constructed in the State of Santa Catarina. Initial excavation and project access construction as well as project detailing started in early August of last year.

When completed in 2010, Salto Pilão will generate 181 MW.
The EPC contract 45 million Euro share for Voith Siemens Hydro, was signed in 2003 and became effective last month through activation of the investor group Consórcio Investidor Salto Pilão, comprising the Votorantim Group (Cements), Camargo Correa Energias SA (Cements) and DME Energia Ltda.

Being fully responsible for the overall supply of the electromechanical equipment, Voith Siemens Hydro will, from June 2007 on, manufacture two 93 MW vertical Francis turbines and two 101 MVA vertical generators as well as other components. The company is also responsible for erection supervision, erection and commissioning. The start of commercial operation of units number 1 and 2 is scheduled for November 2009 and January 2010 respectively.

Four new runners for Moyopampa

Voith Siemens Hydro São Paulo has also recently received a contract by the Peruvian facility Empresa de Generacion (EDEGEL) to refurbish two generating units for its Moyopampa hydro power station. Each unit has two Pelton runners at a rated capacity of 12.5 MW. The first of the runners shall be recommissioned by July 2007.

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Revelstoke starting hydro power series in Canada

With its many hydro resources, rivers and lakes, Canada is rich in its resources of hydro power. Approximately 60 percent of electricity comsumption by Canadians is produced from the power of water. Installed hydro power capacity is about 69,500 MW in this country.

The current project development supports the strong dynamics in the Canadian hydro market. Over the last three years, several projects were launched to ensure new energy supply from renewable sources in the country. Voith Siemens Hydro is pleased to participate in this development with projects like La Tuque, Mercier and Revelstoke.

In September 2006, British Columbia Hydro and Power Authority awarded Voith Siemens Hydro with the delivery of a 512 MW Francis turbine and a 532 MVA generator for the extension of the Revelstoke project. Currently, model testing is being conducted.

The Canadian hydro power market is very active. In the province of Québec alone, projects with a total of 3,000 MW in the next five years are being planned and Ontario and Manitoba also want to expand their hydro power capacities.

Voith Siemens Hydro is prepared for this development and has established a new location in Montréal in order to be a close partner to the Canadian customers. The Montréal location is responsible for marketing, engineering, and project management.

High quality products and the combined expertise of the hydro professionals of the German and the Canadian units of Voith Siemens Hydro guarantee the best possible solution and aim to be the supplier of choice for future projects in Canada.

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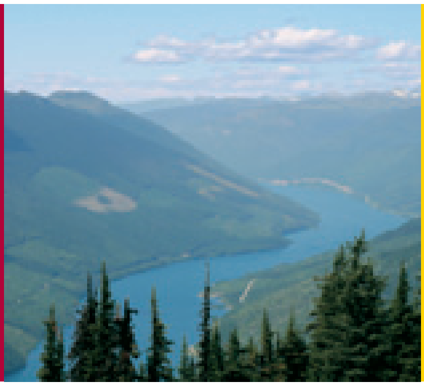

Holtwood plant.

Holtwood expansion project in the US

PPL Generation, LLC of Allentown, Pennsylvania, USA, is studying a proposal for the expansion of its Holtwood hydroelectric plant in conjunction with the plant's Federal Energy Regulatory Commission (FERC) license renewal.

The objective of the expansion would be additional power generation and environmental improvements for migratory fish passage. If PPL goes ahead with the expansion, it would approximately double the generating capacity of the existing plant located in Lancaster County, Pennsylvania, on the Susquehanna River. Contingent on a final decision to proceed with the project, PPL has chosen Voith Siemens Hydro to design two new 65 MW Kaplan turbine generator units, governors, exciters, controls and protection, generator switchgear and related plant and unit auxiliary systems.

PPL selected Voith Siemens Hydro after a complete evaluation of competitive bids as PPL continues to evaluate the project. Manufacture of the equipment will not begin until PPL makes a final decision on whether to proceed with the expansion. No timetable for that decision has been announced.

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50 years of the Jochenstein hydroelectric power station

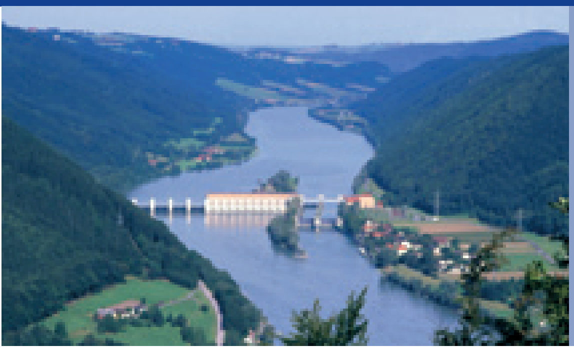
Exactly fifty years ago, in 1956, the Jochenstein Danube hydroelectric power station began operation as the then largest run-of-river power station in Central Europe.

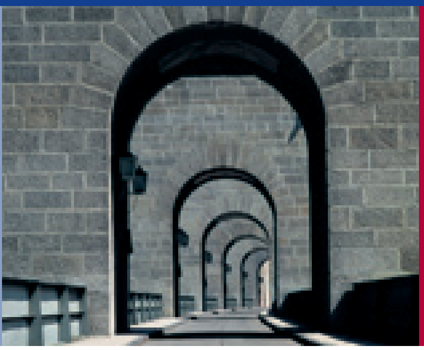
The owner, Donaukraftwerk Jochenstein AG and the operator, Grenzkraftwerke GmbH, have used this occasion to host an event at the power station. High-ranking representatives from the worlds of politics and commerce of Austria and Germany attended the anniversary celebrations.

Voith Siemens Hydro was represented by executives from its German and Austrian operating units.

During a panel discussion, representatives of the owner and politicians highlighted the significance of the power station for the energy industry and the cross-border regional policy.

Jochenstein was constructed between 1952 and 1956 as a cross-border power station following a governmental agreement between the Federal Republic of Germany, the Free State of Bavaria, and Austria. This is why the national border between Germany and Austria runs down the center of the river in the project area.





Each of the five vertical Kaplan turbines generate 29 MW using a flow of 410 cubic meters per second.

To ensure the flow and flood control, the power station is equipped with six sets of weirs. For shipping, two lock chambers were constructed – passage through the locks is free for shipping but entails a power generation loss amounting to 1,000 kWh for the power station.

Voith Siemens Hydro is the supplier of three of the Kaplan turbines and two of the generators. Rehabilitation works on one of the turbines have been executed in 2003, comprising guide bearings, shaft seals, shaft and runner changes, including coated runner blades.

The average annual energy generated is 850 GWh. A fossil-fuelled power station would need to burn 1,900 tons of mineral oil or 2,800 tons of coal to achieve this output. This hydro installation avoids the emission of 7,600 tons of carbon dioxide.

Each year, the 2,000 cubic metres of debris which is removed from the Danube with a mobile rake-type cleaning system, also supplied by Voith Siemens Hydro, is sent for environmentally friendly recycling.

Even after 50 years of operation, the Jochenstein power station continues to be a model for environmentally friendly, long-term energy generation at the highest level of efficiency.

A noteworthy aspect is the way the power station was carefully and harmoniously integrated into the landscape thanks to the beautifully designed facade designs and the use of local stone.

A particularly admired feature is the outstanding architectural design of the structure. It is dominated by a curved line – an extremely rare feature for run-of-river power stations. Also worthy of comment is the design of the weir bridge across the spillway sections, which passes through the arches in the weir columns and, with its granite cladding and striking lighting, creates a scene far removed from purely industrial architecture.

The architectural lines are also picked up visually inside the power station.

As part of the anniversary celebrations, a film illustrating the construction and special features of the Jochenstein power station was presented. This film was produced by a professional film team to celebrate the first 50 years and later broadcast on television and was supported by various partners to the power station, including Voith Siemens Hydro. It is available in German language from the tourist office in Engelhartszell, karin.wundsam@engelhartszell.ooe.gv.at

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Professorship endowed

Enhancing development in hydro

Voith Siemens Hydro is supporting the German facility EnBW's dedication to endow a professorship for hydro power at Stuttgart University for hydro power technology research and development. Voith Siemens Hydro will present its support by placing development tasks for research support at this chair. Scientific support from a third party institution such as a university is often required.

Voith Siemens Hydro and EnBW aim at strengthening scientific expertise and know-how in hydro power technologies in one of Germany's most important research institutions. This way, technical development in the field of hydro power generation is not only enhanced but expertise and skills for engineers in this industry are maintained and improved.

Ghazi Barotha Pakistan

Minister recognizes successful commissioning

Sheikh Rashid Ahmed, Federal Minister for Railways of the Islamic Republic of Pakistan recently visited Voith Headquarters in Heidenheim, Germany. In addition to exchanging ideas with Voith Turbo's Board of Management, he met with Dr. Siegbert Etter, Chief Technical Officer of Voith Siemens Hydro and Martin Andrä, CEO of the German operating unit. He acknowledged the successful commissioning of Ghazi Barotha, a hydro power plant located in Pakistan's northwest region on the Indus River for which Voith Siemens Hydro has supplied five 295 MW Francis turbines. These machines generate clean renewable energy at 97.22 % efficiency, making them one of the most impressive efficiency performances ever reached in a turbine. The Federal Minister also paid a visit to Voith Siemens Hydro's Research and Development facilities in Heidenheim's Brunnenmühle, where the model turbines had been developed and tested.

Ponte Pià Italy

Italian power as a role model for India

The Indian Renewable Energy Development Agency Ltd. (IREDA) is a pioneer in spearheading the movement of renewable energy projects in India by providing financing to small hydro and other renewable energy projects. Ireda has financed more than 100 small hydro power projects in India. During the 2006 year's World Renewable Energy Congress, Sushant Kumar Dey, representing the Ireda, used the occasion to visit the Italian small hydro power plant Ponte Pià, near the city of Trento in the northeast of Italy.

Through 2002 to 2003, Ponte Pià hydro power station was refurbished by Voith Siemens Hydro Italy.
The Voith Siemens Hydro scope of supply included four new horizontal Pelton turbines, generators, controls and automation system.

German-Chilean Energy Forum

Discussing opportunities on hydro power and ocean energy

With the visit of Dr. Michelle Bachelet, President of the Republic of Chile, having a thematical focus on renewable energies, the University of Leipzig hosted a German-Chilean Energy forum. This represented a particularly suitable platform for exchanging ideas with Germany's suppliers of renewable energy technologies. Due to the tight schedule, only few from a large number of industry representatives could participate, among them Dr. Peter Wengefeld of Voith Siemens Hydro. Chile's delegation, with Karen Poniachik, Minister for Energy, Alvaro Rojas, Minister for Agriculture and Carlo Alvarez, Director of Chile's Investment Promotion Corporation, gathered the latest information on renewable technologies and discussed opportunities for German firms to develop projects in Chile, including Voith Siemens Hydro's activities in the field of ocean energy.

Our responsibility as an equipment supplier

Interview with the CEO of Voith Siemens Hydro, Germany.

Dr. Hubert Lienhard

Dr. Hubert Lienhard is also a Member of the Board of the International Hydropower Association (IHA) and currently holds the Chair of the Board of Hydro Equipment Association (HEA)

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Question: Dr. Lienhard, why do you think an industrial company in hydro power generation should be concerned with social responsibility?

Dr. Lienhard: In my opinion, we have clearly experienced over the last years an increasing number of critical themes around hydro power that may very well and quickly turn into serious threats if not properly dealt with: poor project implementation has damaged part of hydro's good image as clean and renewable source for power generation. Think of resettlement issues, debates on compensation of affected people, change of living and nutrition for indigenous people. All this has become much too relevant to be ignored, even if true for a relatively low number of projects. We must start getting involved in this debate and show that hydro power is an energy worth fighting for in the sense of an emissions-free and Kyoto-supportive solution to future energy supply.

Question: So, how does the company view this responsibility?

Dr. Lienhard: First of all, we, the industry, must simply open our eyes and accept the presence and role of stakeholders, instead of only defending hydro power as always good, clean and innocent. To begin this dialogue is a first step in a sorely needed new mindset to go forward.

If you look at our engagement in the industry associations (IHA and HEA), that is one fundamental step. But continuing this dialogue with stakeholders, especially NGOs, and bringing them closer to the industry and these associations joins forces for all of us.

"Hydro power is an energy worth fighting for."
Dr. Hubert Lienhard

The other step is, to do this as a company directly. Since the experience of a World Commission on Dams (WCD) process and its follow-up discussion in the public area, up to the development within political frameworks against hydro, we have to accept that only we can be the ones to fight for the good image of hydro power.

Question: What has Voith Siemens Hydro done so far?

Dr. Lienhard: Voith Siemens Hydro was a founding company in the establishing in of the Hydro Equipment Association in 2001.

I myself have started to talk about our problems very clearly and as often as I can: We have talked to NGOs on common ground; I have presented to our customers, to partners, to banks, to my own management and staff.

Question: What do your communication activities embrace above this?

Dr. Lienhard: HEA has launched a new PR campaign, highlighting not only the benefits of hydro power alone, but emphasizing the need to reconcile the effects in an economical, social and environmental context in the best-possible way. This is only possible through intensive consultation and participation.

Question: Are there any concrete project acitivities as a company you are pursuing beyond your core business, then?

Dr. Lienhard: Yes, we are planning to prove that we want to go beyond our mere business approach and enter into concrete activities for improvement in project realization:

1. By absolutely propagating the IHA Sustainability Guidelines and the relating Assessment Protocol to owners and operators. These guidelines and this protocol, by the way, have found great acknowledgement from the political and NGO side during the last Nairobi Climate Conference.
2. By entering into further dialogue with NGOs that are willing to talk to us and to share responsibility for improvement in project realization.
3. By investigating project options helping to reconcile bad effects after the implementation of a hydro power plant. For this, however, it is still too early, but we are on our way.

"We are no longer interested in the large or the small, but the well planned and well managed."
Dr. Klaus Töpfer, during his time of UNEP chairmanship.

Question: What are your expectations for the years coming on being taken into responsibility actions?

Dr. Lienhard: Well, I assume, we will network and exchange much more intense in much earlier stage of projects than ever before. We will have to get involved into discussions on stakeholder participation and public consultation as never before. And we have to be ready to do this with a well-informed and trained sales force that is also able to understand and exchange this with our partners, customers, consultants and others.

Looking or staying away from problems is no solution any longer. Looking at it, and trying to help develop solutions on common ground for all, will at the end really provide sustainable hydro power projects according to generally accepted standards.

IHA Sustainability Guidelines

Sustainable development is regarded by IHA and HEA as a fundamental component of social responsibility, sound business practice and natural resource management. Sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs (Report of the World Commission on Environment and Development, 1987). It requires the integration of three components – economic development, environmental caution and social justice – as interdependent, mutually reinforcing pillars.

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Dr. Hubert Lienhard, CEO of Voith Siemens Hydro, and Jaime Pinkham of Columbia River Inter-Tribal Fish Commission.

Linda Church Ciocci, National Hydropower Association and Alessandro Palmieri, World Bank.

Audience discussing during book introduction.

Voith Siemens Hydro helps promoting book on 'The Power of Water'

A new book supported and promoted by Voith and Voith Siemens Hydro unfolds a diversity of view points on hydro power.

The book 'The Power of Water' was introduced to the international audience in a public event during HydroVision 2006 conference in Portland, Oregon. A panel, chaired by Linda Church Ciocci, Executive Director of the US National Hydropower Association, Dr. Hubert Lienhard, CEO of Voith Siemens Hydro, together with Dr. Alessandro Palmieri of the World Bank, and Jaime Pinkham of the US-based Columbia River Inter-Tribal Fish Commission, reflected on the diverse views of this book for the readership.

The book, published by Deutsche Verlagsanstalt (DVA) in Germany, contains a wide range of voices on hydro power and its related issues, from prominent environmentalists, such as Achim Steiner – today's head of UNEP, Dr. Klaus Töpfer, his predecessor in UNEP, Kader Asmal, as the former head of the World Commission on Dams, World Bank representative Alessandro Palmieri, to Richard Taylor from the International Hydropower Association, a welder of turbines in Voith Siemens Hydro, an Indian Chief in Canada, and a boat rental owner on a German storage lake.

Other chapters are devoted to the hydro industry's history, technical solutions in energy from water, the future potential of hydro power, and water management on the Colorado River.

The book was edited by Frankfurter Allgemeine Zeitung journalist Georg Küffner, and can easily be read by picking and choosing chapters in any order.

During 2006 introduction at the HydroVision, there was no doubt, that such a book is beyond traditional technical or political iterations on hydro power and clearly showed that the times of narrow views within the industry are over.

Jaime Pinkham brought the tribal perspective to the round and was happy to see that "the book helps drive us towards a common understanding" and that "hydro power projects in developing countries could benefit from the experience in the Pacific Northwest of the US, where a struggle continues to try to restore salmon runs".

Dr. Lienhard once more emphasized the fact that the industry – by supporting this diverse arrangement of views on hydro power – definitely shows the increasing involvement of corporations beyond their financial goals, and the rising awareness of the need of common ground for sustainable realization of hydro power plants.

The book is available in English from HCI Publications at info@hcipub.com; www.hcipub.com.

The German version can be purchased through Germany's book sales under
ISBN 13: 978-3-421-04214-9.

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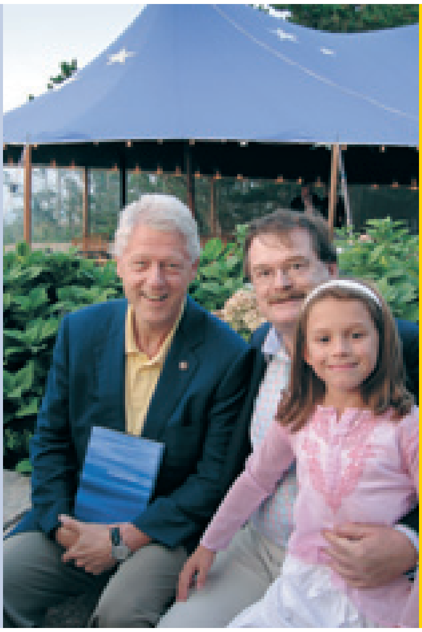
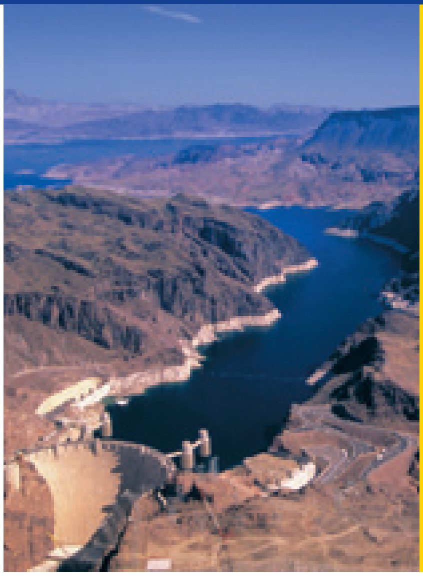
HydroVision 2006,
Voith Siemens Hydro booth.



The most prominent reader of the book so far: Bill Clinton received his copy for his 60th birthday from Wayne Rogers of Voith Siemens Hydro's developer Synergics and his little daughter Kellyn.

The Greenhouse Gas story: UNESCO convened workshop in Paris



The debate associated with Greenhouse Gas (GHG) emissions from freshwater reservoirs has met with differing views so far from national legal bodies, international climate change institutions, NGOs and the hydro power industry.

The debate was not so much focused on the fact that emissions occur, but rather on the incremental proportion, if any, that is related to human activity and blamed on reservoirs from hydro power generation.

Besides the IPCC (Intergovernmental Project on Climate Change) working group with three varying methodologies, the Executive Board of the UN Framework on the convention on Climate Change's Clean Development Mechanism had introduced another set of criteria in January 2006 that threatened to exclude hydro power schemes with significant water storage from this mechanism.

The UNESCO December 5 - 6 workshop in Paris brought together government officials, scientists and reservoir managers to review previous and current research and field measurements, assess common understanding and identify knowledge gaps, define future research needs, and identify roles for future work.

The problem of GHG emissions from hydro relates only to the understanding of methane fluxes at shallow-plateau type tropic reservoirs. Therefore, all other hydro schemes should be considered to have a very low GHG footprint.

Further research needs to be done in order to have a reference organization, the "Reservoir Emissions Forum", which should be in a position to guide and review future initiatives, with UNESCO willing to host the effort with support from national governments.

A steering committee will be formed with up to four representatives for each of the science, industry and government categories.

IPCC has written to International Hydropower Association (IHA) to invite participation as an observer in the IPCC Working Groups I, II and III, and to its general meetings. Both IHA and HEA (Hydro Equipment Association) have welcomed this result from the workshop for a future, scientifically based approach on this theme.

What are Greenhouse Gases (GHG)?

The emission of GHGs has been stated to have a direct, man-made influence to world climate, resulting in global warming and relating climate effects. Therefore, the global reduction of emission of GHGs is the central goal of the Kyoto Protocol of 1997 for many nations. The most important gases, concerning the discussion on emission from reservoirs and flooded lands, are carbon dioxide (CO_2) and methane (CH_4). Other gases, as defined in the Kyoto protocol, are nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocabons (PFCs), and sulfur hexafluoride (SF_6).

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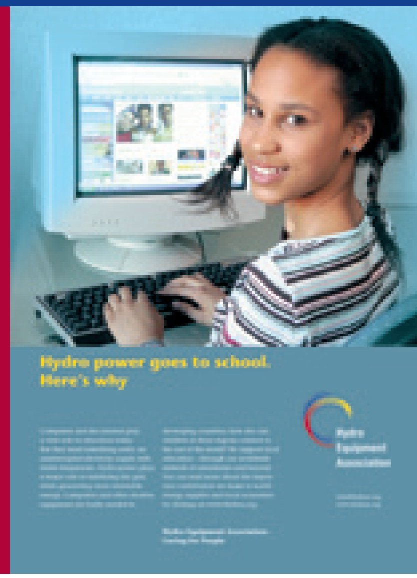

Hydro Equipment Association launches PR campaign

In its effort to support public recognition of hydro power and maintain the dialogue among stakeholder groups, the Hydro Equipment Association (HEA) has launched a new ad campaign in fall 2006. The advertising concept picks up on the potential and value of hydro power for people, economies and the global environment.

With the help of three themes, the campaign focuses on the areas of work, education and food. Its aim is to highlight the advantages of this renewable energy source, which supplies one fifth of the power generated worldwide, and to address potential reservations the public may have. At the heart of each theme are people, pictured in their everyday environment, who serve as prime examples of the benefits that hydro power brings.

Founded in 2001, HEA is a group of manufacturers of hydro equipment. In the light of existing controversy about dams, its main objective is to promote the dialogue between different stakeholders, to highlight the advantage of hydro power for low-emission energy generation and, with the help of industrial policies, to secure the socially and environmentally acceptable realization of hydro power projects. Its three major members are Voith Siemens Hydro, Alstom Power Hydro and Andritz VA Tech Hydro.

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Joint venture for tidal current power in South Korea

Voith Siemens Hydro has signed a memorandum of understanding for the foundation of a joint venture with Renetec, a Korean corporation that drives project development in the renewables energy sector since 2001.

The joint venture pursues the development and testing of machines for energy generation from large tidal power plants. Voith Siemens Hydro will hold 51 %.

Partners for a proposed tidal current power plant are Korea Hydro & Nuclear Power Company, Korea-based steel manufacturer Posco, and Jeonnan Provincial Government and Renetec, all shareholders to Korea Current Power – the future operator. Joint venture partner Renetec, since its foundation, has had a close relationship with the Institute of Fluid Mechanics and Hydraulic Machinery of the University of Stuttgart (IHS) in Germany.

This cooperation has seen the development of a project to be implemented in Korea's Wando province.

The technology for this type of tidal current power station is essentially different from the traditional approach of tidal power stations: instead of using a dam to retain the sea water and extract its potential energy with bulb-like turbines, free-flow turbines extract the kinetic energy of the passing sea water. Prototypes of machines will have a rated power between 600 kW, and 1 MW. Final implementation of the tidal energy park in Korea will see an overall installed capacity of 600 MW.

Dr. Hubert Lienhard, CEO of Voith Siemens Hydro in Heidenheim, Germany, clearly views this project to be a another milestone in the company's way towards energy generation through marine technologies. "With this entry into ocean energies, we are expanding our traditional hydro business beyond our core and will contribute new and innovative solutions in wave and tidal energy generation," he said during the signing.

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Dr. Siegbert Etter, Corporate Technology Officer and his presenters during the Voith Siemens Hydro seminar.

Seminar on silt erosion in New Delhi

India has a huge unharnessed hydro potential of 115,000 MW. A major portion of this potential is in the northern and north-eastern Himalayan regions of the country. The high silt content in the waters of the Himalayan Rivers and the resulting fast wear of turbine parts has been a matter of great concern in recent years.

To address this very important subject, Voith Siemens Hydro had organized a one-day seminar in New Delhi on October 10, 2006. Over 120 delegates from all parts of the country, representing leading owners and operators, governmental institutions, the private sector, as well as a large number of leading consultants, participated in a highly interactive seminar with Voith Siemens Hydro's panel of speakers.

The presentations were aimed at creating a deeper understanding among Indian participants on the factors causing erosion and for joint approaches in finding tailor-made solutions to mitigate the associated problems.

The aspect of abrasive wear, was a topic addressed again by Voith Siemens Hydro experts during their presentations in the Power India Conference, held later in Mumbai, from October 12 - 14. In this conference, a case study on the Three Gorges hydro power project was also presented.

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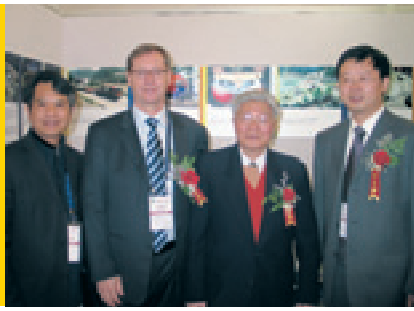
The Voith Siemens Hydro team in Beijing.



Pan Jiazheng (second from right), Academician of Chinese Academy of Science and Chinese Academy of Engineering, visited Voith Siemens Hydro during the event in Beijing.

Vienna "Heurigen" atmosphere during 14th university-held seminar.

International hydro events in Beijing and Vienna

The 1st International Conference on Hydropower Technology & Key Equipment was held in Beijing from October 27 - 30, 2006, sponsored by China Three Gorges Project Corporation and the China Society for Hydropower Engineering. Also, from November 22 - 24, 2006 the International Seminar on Hydropower Plants of the Vienna Technical University took place for the 14th time, in Laxenburg, Austria.

About 500 domestic and international experts, students and engineers of the hydro power industry as well as high-level management from large hydro power plants and corporations were attracted by the Chinese conference. Along with national and foreign equipment manufacturers, Voith Siemens Hydro Shanghai presented itself with a booth and papers on large hydraulic machinery, based on its outstanding experience with the hydraulic design developed for the Three Gorges units.

The rapid hydro power development in China has entered a new period that Voith Siemens Hydro hopes to participate in considerably.

The Vienna event under the title "Worldwide use of Hydropower in the future" was attended by more than 200 participants, primarily from the European Union.

Organized by the Institute for Waterpower and Pumps and the Institute for Testing and Research in Materials Technology of the Vienna Technical University, this event offered the opportunity to Voith Siemens Hydro to present on technical developments and highlights of projects, such as automated Finite Element Analyses electrical machine design, integrated solution for monitoring and diagnosis, new joint control at Bratsk, modernization of Zakucac, numerical simulation and design of spherical valves for pumped storage, and new challenges for modern pumped storage units.

Voith Siemens Hydro, above this, presented itself with a booth and sponsoring of the welcome reception in a typical Viennese "Heurigen" location.

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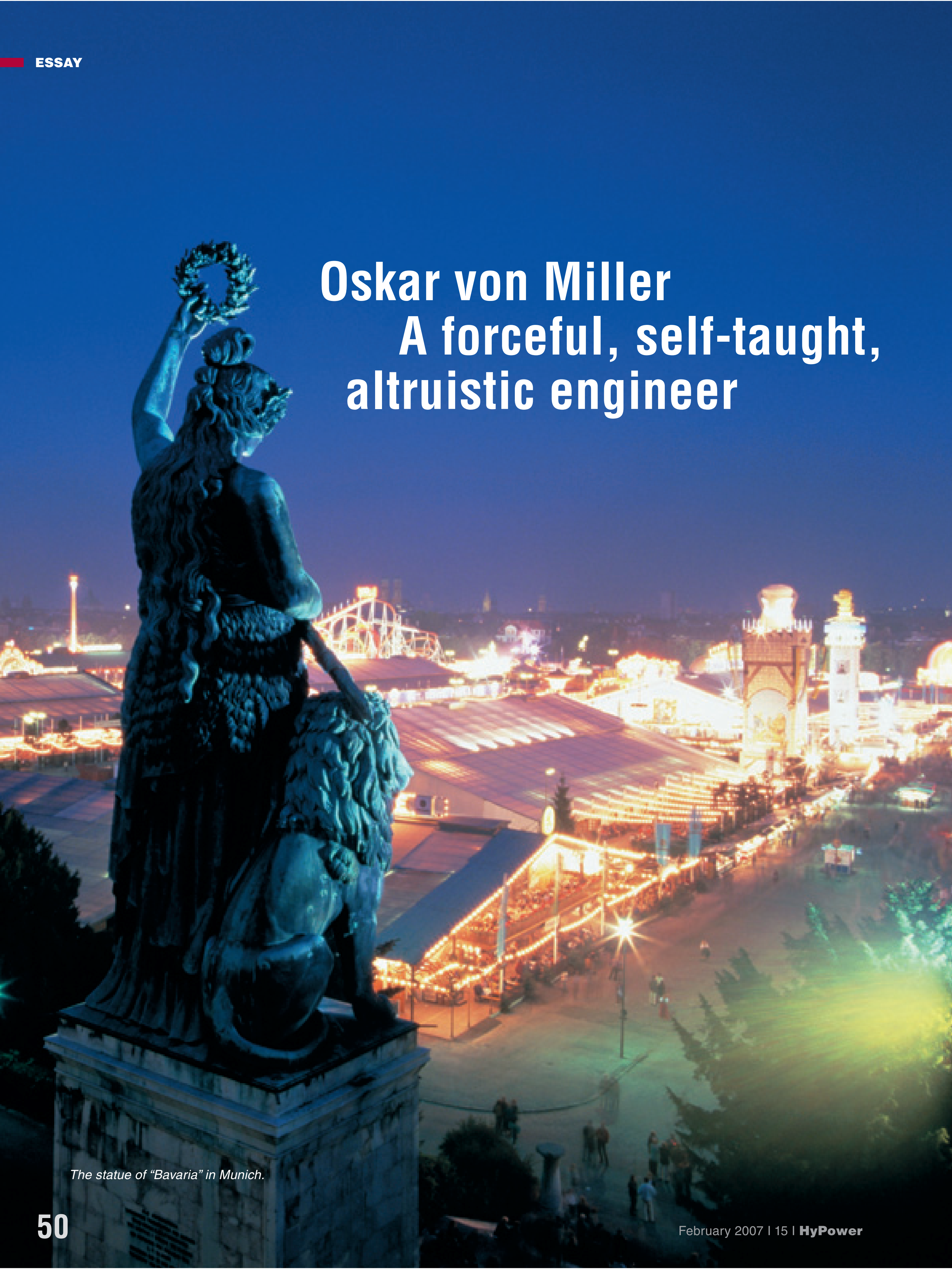
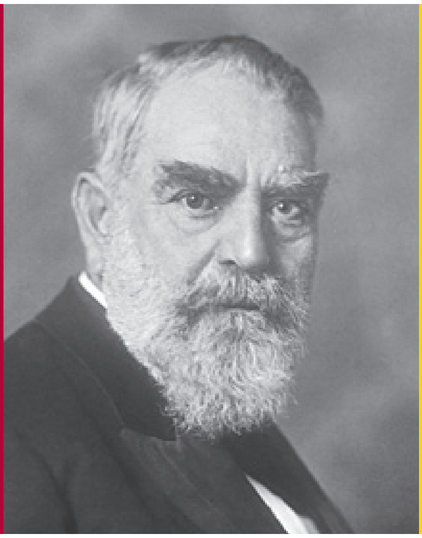
Conferences, seminars and symposia

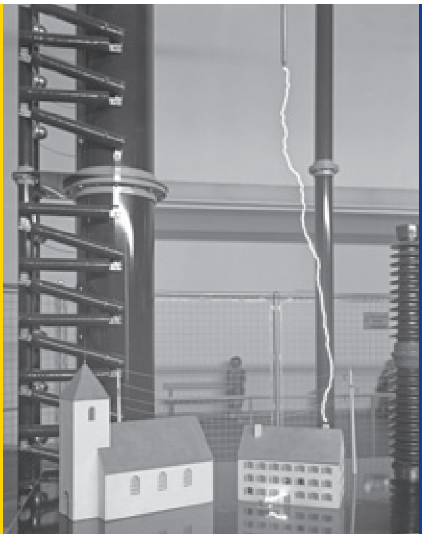
Date	Event/further information
March 15 - 18, 2007	**US National Hydropower Association (NHA) Annual Conference** Washington, D.C., USA US National Hydropower Association www.hydro.org
May, 27 - 31, 2007	**World Congress on Advancing Sustainable Hydropower and International Training Course in Hydropower Sustainability Assessment** Antalya, Turkey International Hydropower Association www.hydropower.org
July 23 - 26, 2007	**Waterpower XV** Tennessee, USA HCI Publications www.hcipub.com
October 15 - 17, 2007	**Hydro 2007** Granada, Spain Network Events and International Journal on Hydropower and Dams www.hydropower-dams.com
October 22 - 25, 2007	**CIGRE Joint Colloquium on Insulation systems for electrical machines, and SC A1/SC D1 Meetings** Kyenongju, South Korea CIGRE Study Committee D1 and A1; Korea National Committeee of CIGRE, KIEE and C Society; http://www.cigre-a1.org/Site/Events/pa_ce.asp
November 11 - 15, 2007	**20th World Energy Council Congress** Rome, Italy World Energy Council www.rome2007.it

Oskar von Miller
A forceful, self-taught, altruistic engineer



The statue of "Bavaria" in Munich.





Oskar von Miller.
Born 1855, died 1934 in Munich.

Lightning model in the high-voltage apparatus.

The Deutsche (German) Museum in Munich.

The life of one of Germany's leading electrical engineers.

Oskar von Miller was one of the most significant personalities in the German electrical engineering scene in the final decade of the 19th and the first third of the 20th centuries. As a self-employed engineer and a talented organizer and fund-raiser, he was able to transform a multitude of small electricity supply networks, together with his contemporaries, into just a few larger ones. He often "pushed the envelope" in his thinking but avoided going too far. He understood his fellow men extremely well, and his suggestions were always realistic. Furthermore, he was altruistic in that his goal was the common good.

He was unpopular in the electrical engineering trade, his chosen area of business, because he forced the prices down so that everyone could afford electricity.

His father, Ferdinand Miller (the "von" was added to the family name when he was elevated to the aristocracy), ran a foundry in Munich. The statue of "Bavaria" in that city is his work. Oskar Franz Xaver was the youngest of fourteen children. He exhibited very little enthusiasm for school or as a student of construction engineering. The engineer's pragmatic approach suited him but failed to capture his interest. His talent was in issuing orders rather than obeying them.

When the International Electrical Engineering Exhibition was held in Paris in 1881, Miller, with some difficulty, succeeded in being seconded to it as Bavarian state commissioner. His knowledge of electrical engineering was minimal, but he soon taught himself the necessary rudiments. For the rest of his life, Miller built on what had begun in Paris in 1881. His gift was for planning and organization.

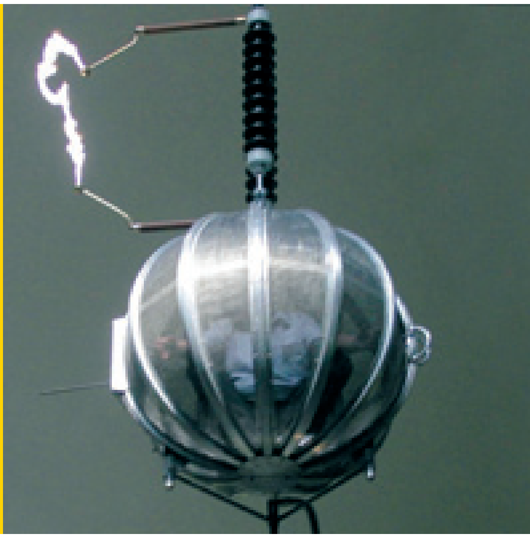
In 1882 he played an important part in Munich's "Electricity Exhibition". In 1891 he was director of the Electrical Engineering Exhibition in Frankfurt. As a highlight of this event, he organized the transmission of three-phase current along a 175-kilometre long, 20,000-Volt line from Lauffen am Neckar, to Frankfurt.

This successful experiment led to large areas of Germany being supplied with electricity, and to a gradual change from small direct-current power stations within cities to more remotely situated alternate current power stations. Miller was aware of the superiority of the new generating machinery, and rose to be one of the country's leading electrical engineers.

From 1883 to 1889 he was Director of the German Edison Company (later AEG) in Berlin. After this, he worked as a freelance engineer in Munich for the rest of his life. For these 45 years, he was his own lord and master, and, in this same period, electrical engineering grew into what we are familiar with today: the many small supply networks were replaced with just a few large ones. Miller played a significant role in this development.

Lake Walchensee in Bavaria, Germany.

This experiment shows the effect of AC voltage.



Test arrangement for AC voltage.

From 1918 to 1924 he was project manager for the Walchensee power station, at that time the largest hydroelectric power plant in the world. Four years later he began to draft out a general electricity supply plan for the whole of Germany. His books on urban power supply became standard works of reference.

According to his biographer there was also another side to Oskar von Miller's character: he was a "fearsome despot", a workaholic, a skinflint and a Bavarian who sported a beard worthy of the legendary giant Rübezahl. Worse still: von Miller was so domineering a character that he even corrected his wife's diary entries. His children walked to school, which took them 45 minutes, because he was too mean to pay for the tram tickets.

He regularly forbade his employees to take the holidays to which they were entitled, and when he was commissioned to draw up surveys, he often used them as a means of landing lucrative orders later. What is most fascinating about Oskar von Miller is that although we would hardly like to use him as a role model, he nonetheless earns respect for his visionary and entrepreneurial attitude.

"I want people to pour into the museum as they would visit the beer tents at the Oktoberfest."
Oskar von Miller

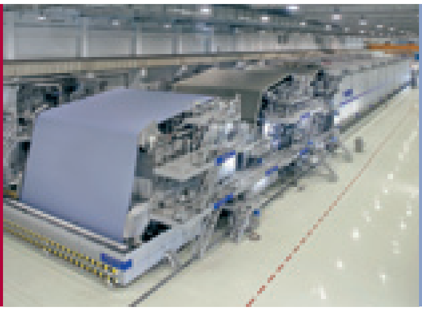
Oskar von Miller's greatest work was the German Museum in Munich. His aim was for talks to be given there and for visitors' curiosity to be aroused by interacting with hands-on experiments, rather than just observing the exhibits.

This project enabled him to exercise all his talents. He planned, organized, persuaded and begged until he had everything he wanted.

He performed the entire task in a volunteer capacity, though it also represented good publicity for his consulting engineers' office.

The museum was founded in 1903, but after the upheavals caused by the First World War, it was not until 1925 that the permanent buildings were opened on an island in the Islar River. Oskar von Miller died of a heart attack on April 9, 1934.

The pictures in page 51 are kindly supported by the German Museum.



Voith Paper

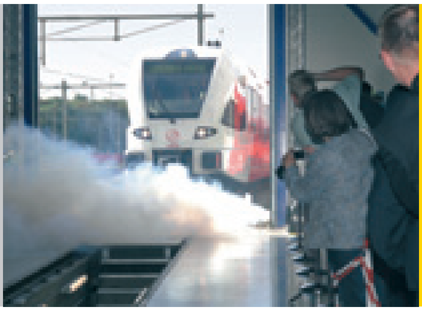
A new record for Voith Paper was achieved with the new production line PM 12 at Huatai Paper Company Limited in Shangdong, China, that was successfully started only five months after erection of the new paper machine had begun.

PM 12 will produce high-grade newsprint for four-color offset printing. The new paper machine is the “sister” machine to PM 11 also supplied by Voith Paper in 2004. With a design speed of 2,000 meters per minute, a wire width of 10.2 meters and an enormously high production capacity of 1,210 tons per 24 hours by 49 grams per square meter, the PM 12 will join PM 11 as one of world’s largest and fastest newsprint production lines.

Voith Paper Automation’s total process know-how was completely incorporated into the engineering of the instrumentation and functional design of the recycled fiber preparation plant, the additives preparation section and also the machine-related control equipment. This was a significant reason for the fast start-up of the PM 12.

The PM 12 is the fourth paper machine in this series supplied by Voith Paper to Huatai Paper. It will ensure Huatai to maintain its position as the number one producer of newsprint in China, both in terms of quality and quantity. Production of high level newsprint at Shandong Huatai Paper will reach an amazing 1.2 million tons by the end of 2006, which will equate to almost 50 % of the entire newsprint production in China – all produced on Voith Paper machines. The trust placed in Voith Paper by Huatai Paper reflects the long history and close cooperation between the two companies.

Voith Paper is a division of Voith and one of the leading partners to the paper industry. Through steady innovations, Voith Paper optimizes the paper production process. More than one third of worldwide paper production is produced on Voith Paper machines.



Jörg Fiedler, Executive Vice President of IAP Technology GmbH, and Peter Edelmann, CEO of Voith Turbo and Member of the Board of Management of Voith AG.

Voith Industrial Services

Voith Railservices B.V., a Voith Industrial Services company, has opened a new workshop in Leeuwarden, Netherlands, built for the purpose of performing repairs on 43 Stadler trains of Arriva Openbaar Vervoer NV. Construction took place February to August 2006.

Two sets of tracks in the workshop enable maintenance work to be carried out on two trains simultaneously. If necessary, a third railcar can be set up on an additional track next to the building. Arriva awarded the contract for repairs for a period of 15 years. In the future, Voith Industrial Services will be responsible for maintenance and analysis of improvement potentials in the trains and the maintenance plans. To do this, Voith Industrial Services works closely with railcar manufacturers and railroad transportation companies in the Netherlands. Voith Industrial Services is a leading provider of technical services for key industries with over 150 sites worldwide, more than 15,000 employees, and sales of around € 700 million in the past fiscal year.

Voith Turbo

During this year's IAA Commercial Vehicle Show, the Boards of Voith Turbo and IAP Technology announced the integration of IAP Technology into the newly established Voith Turbo Aufladungssysteme, based in Gommern, Saxony-Anhalt, Germany.

With this step, Voith Turbo and IAP Technology are pooling their activities in the field of turbochargers for combustion engines.

Voith Turbo Aufladungssysteme will thus concentrate and intensify its activities relating to turbocharger technologies for commercial vehicle combustion engines. The existing location in Gommern will be used for series' development, as well as series' production of exhaust gas turbochargers, which will start in 2008. Presently, the newly founded company is operating its own research and development center, staffed with a team of over 25 design engineers, working on solutions for growing demand with regard to engine output, emission regulations, fuel consumption and reliability.

The development period is expected to provide positive results of pre-series tests and shall supply the commercial vehicle industry with series-produced exhaust gas turbochargers from 2008 on.

Voith Turbo, the specialist for hydrodynamic drives, couplings and braking systems for road, rail and industrial applications, as well as for ship propulsion systems, is a Group Division of Voith.

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