HyPower

Customer magazine
from Voith Siemens Hydro Power Generation

12

December 2005

Summary

Editorial

Voith Siemens Hydro Power Generation

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

Dear readers and customers,

We finished the fiscal year in September 2005. Looking back at this year, I am pleased to say that we have not only achieved our corporate goals, but we were also able to start some things beyond our regular efforts.

We are clearly focused on complete plant supply and overall assessments. This includes new equipment, modernization and optimization of systems of varying degrees for the maximum technical performance of hydro power plants. We offer highly developed tools and solutions to improve our customers' return on investment.

Furthermore, however, we focus on the whole picture of political, environmental and social impacts of energy generation, and we engage in the discussion of which type of energy production is most beneficial for individual application.

With regard to emerging technologies, we acquired Wavegen, which is one of the technical leaders in wave energy and the only enterprise to operate a pilot plant not only for testing, but also for uninterrupted supply of electricity to the grid. This new technology, we believe, can for example provide remote islands with energy systems that bring emission-free and renewable generation to its population – as may be in the case of Tonga. It offers independence of fossil fuel imports as a highly attractive add-on.
For us, this strive is a clear indication of the heightened awareness for urgently needed options in the energy supply of the future. However, if you look at this year's public and political debates, it seems that the solutions stay unclear.

Hydro gets political

What concerns me most of all, is the exclusion of hydro within global energy solutions. Some guidelines, currently debated, threaten hydro's contribution to a sound and responsible generation mix for many nations. For example, current greenhouse gas inventories charge hydro power reservoirs with CO_2 emissions on a general range, deriving results from a handful of studies undertaken so far. In our opinion, this grossly misinterprets the true causes of these emissions, and hydro reservoirs seem to be an easy target.

At the same time that we see growth potential, we are frustrated by the inability to move forward and reduce global CO_2 emissions to satisfy Kyoto and other climate change programs. It seems that a comprehensive approach is not of interest in most of the ongoing political processes.

It is time that we as an industry stand up, work with political allies and investors and clearly promote the benefits that hydro brings. You are welcome to join the coalition of stakeholders and industry associations to work toward what we think is second to none in renewable and emissions-free generation and must continue to play an essential role in the energy future of our world, instead of blaming "our" reservoirs!

We are interested in your opinions and comments; please feel free to direct them to me personally.

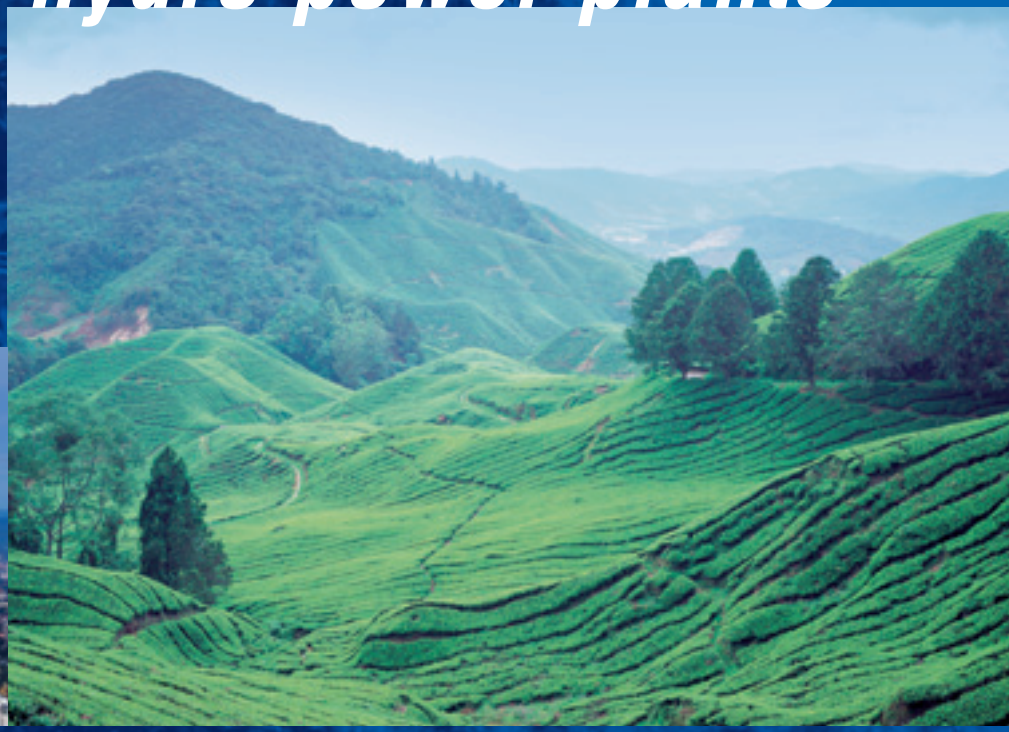
My e-mail address is Hubert.Lienhard@vs-hydro.com

Yours sincerely

Hubert Lienhard

Focus on technological leadership

Maximum efficiency for hydro power plants



In view of the ongoing trend toward liberalization of the energy markets, demand for cost-efficiency and intelligent hydro plant operation is bound to intensify in the years to come. But there is more to it than just economics. Effective plant management can do a lot to actually make use of the full potential of existing hydro power stations, and thus to enhance the utilization of clean, sustainable energy. The development of cutting-edge automation and control and monitoring is just one way in which Voith Siemens Hydro contributes to the continuous improvement of plant performance. To ensure that, Voith Siemens Hydro has developed the HyCon family, an automation system, which as a multifunctional approach offers a number of highlights.

Plant automation: Engineering know-how makes the difference

The need to process the immense amount of information necessary to control a hydro plant's vital functions calls for a high level of automation. This might suggest that high-tech software is the answer, but it takes a lot more than that to develop a technologically advanced solution like HyCon: It is the plant engineering know-how that is at the core of a leading-edge automation system.

Having developed and built thousands of machines, Voith Siemens Hydro is able to tailor an advanced modular system to your specific needs – even when multiple plants with different types and sizes of machines have to be equipped with a uniform control technology. Highly flexible systems allow for completely customized automation concepts.

In the case at the Cameron Highlands hydro power stations in Malaysia, the group of seven plants located in the central highlands north of Kuala Lumpur is currently being automated. In order to extend the lifetime of these plants, built between 1959 and 1963 with a total installed capacity of 263 MW, most of the mechanical and electrical auxiliaries will be replaced along with the installation of a new control system.

Voith Siemens Hydro, responsible for the mechanical and electrical rehabilitation, will deliver a complete control system for the Jor, Woh and Habu plants, and will equip a central control room for the whole group of plants.

Habu, a small hydro plant with two Francis units designed for remote operation, requires a rather compact and cost-saving solution. To keep costs at a minimum, the complete unit automation and the on-site control panel are integrated into a single cabinet – a solution where all functions of the HyCon 400 control system are integrated in a special "all-in-one" configuration. At the Jor hydro power station with its four 25 MW Pelton units and Woh with its three 50 MW Francis turbines, priorities are different. Here, high availability is the most important factor, so distributed control architecture is needed. For these plants, fully redundant servers are provided with a hot standby backup system.

Control room testing

Intake at hydro power station Woh, Cameron Highlands.

Focus on technological leadership

Similarly, the central control room is equipped with redundant servers and an additional historical archive computer, automatically storing all relevant data. From here, the HyCon 400 system allows the operator to monitor the functions of all of the hydro plants. It also features the full range of on-site operating possibilities provided in the system, for example, the ability to manually operate drives and switches. Reliable communication is another important aspect for the operator of the Cameron Highland power stations. By implementing two process buses as separate units, completely independent of and isolated from one another, communication can always be maintained.

Access to all PLCs (programmable logic controllers) from the local control rooms in Jor and Woh, as well as from the central control room, can be guaranteed at any time. Installation is underway.

Its reputation for excellent reliability was a significant reason why the HyCon 400 control system also was installed at the Brazilian 160 MW hydro power station Pedra do Cavalo. The brand-new plant, which began full commercial operation in January 2005, provides almost 800,000 people in the Brazilian state of Bahia with electricity, and significantly reduces the risk of blackouts in the region. Therefore, it is most important that the plant functions as a stable source of electricity for many years to come.

This requirement also applies to the control system. HyCon 400 meets this demand in many ways: not only is it based on Siemens SIMATIC S7 technology, renowned for its highly reliable long-life components and globally available spare parts. Its software has been developed exclusively for the special conditions in hydroelectric generating facilities.

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Detailed information is provided in our brochure HyCon 400, t3302 e.

Pedra do Cavalo, Brazil

Salvador, Bahia, Brazil

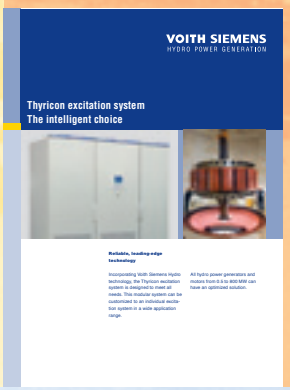
Excitation with maximum reliability and performance

The energy that a hydro generator produces is worthless unless it can be supplied to the power grid. It is the job of the excitation system to guarantee that this energy can be transferred, and therefore, the priority is on reliability, fast voltage responses and the utmost stability: requirements that are fully met by Thyricon excitation system.

Incorporating Voith Siemens Hydro technology, the Thyricon excitation system is designed to meet all needs. This modular system can be customized to individual needs in a wide application range. All hydro power generators and motors from 0.5 to 800 MW can be provided with an optimized solution.

Thyricon offers reliable software and hardware; its technology is based on standard Siemens hardware. A worldwide network assures total availability of spare parts at any time. The excitation system is equipped with digital voltage regulators that allow a fast grid response. A power system stabilizer, minimizing power oscillations, can be added.

Detailed information is provided in our brochure Thyricon Excitation system – the intelligent choice, t3307 e.



Focus on technological leadership

The Thyricon excitation system controller is a user-friendly Human Machine Interface (HMI).

Easy visualization is of great importance, and trend functions are displayed on the operator panel to help speed up commissioning and maintenance.

The energy-saving qualities of this highly-efficient system make it the best choice, not only for new installations. Since the product can be integrated into existing power stations and control systems easily, it is also a most suitable solution for modernization and rehabilitation projects – as is the case at Piva hydro power station, Montenegro.

The first of three 120 MVA generator units was retrofitted this summer; modernization of the others is to be finished soon.

Thyricon excitation systems have been operating in around 500 hydro power stations all over the world, with excellent results.

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Piva hydro power station, Montenegro

Governing system: Hybrid servomotor easens maintenance

The ability to control a hydro power plant and the quality of the electric power it provides largely depends upon the performance of the governing system. The governor maintains the turbine speed and regulates its output.

Small to medium sized hydro power stations have increasingly been equipped with governors with a motor operated servomotor. However, this reliable and easy-to-maintain system calls for a much larger footprint than the conventional pressure oil operated servomotor.

Voith Fuji Japan has developed a way to combine the advantages of both size and ease of maintenance, by using ultra high oil pressure.

By boosting the pressure from a conventional 6 MPa to ultra high 10 MPa and integrating the pressure oil system, control valves and pump set into a single component, the size of the servomotor system has been reduced and its structure simplified.

The 10 MPa Hybrid servomotor system is directly driven by a reversible pump and controlled by a DC servomotor and a digital governor.

The oil pressure tank, compressor, sump tank, distributing valve and many control valves are no longer necessary. Installation is easy and no piping is needed. Over recent years, several plants in Japan have already been equipped with hybrid servomotor systems with excellent customer feedback.

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Hybrid servomotor installation at Kubusugawa, Japan.

Vibration diagnosis: Efficient preventative maintenance

The complex excitation mechanisms and the large scope of dynamics in operational transitions make high demands on measurement, data processing and evaluation procedures. The interpretation and diagnosis of vibration behavior of a hydro power unit requires an enormous amount of data.

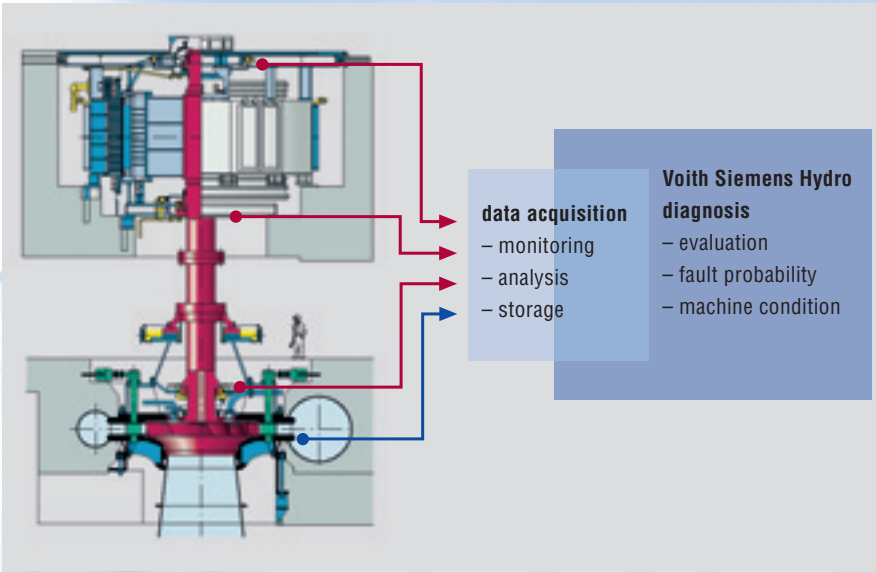
The HyCon vibration diagnosis system is capable of compressing large amounts of measurement data into a manageable and comprehensive set of information, thus enabling continuous monitoring and archiving, which in turn allows for long-term evaluation of machine conditions.

Furthermore, HyCon vibration diagnosis incorporates a deep comprehension of the functional relation between vibration causes and effects. It integrates the profound knowledge of hydro technology accumulated over decades of development, manufacturing and operating hydroelectric machinery. In the event of abnormal vibration behavior, different error pattern probabilities are processed.

This enables the causes of major known abnormalities to be clearly identified and remedial recommendations are provided. By remote connection to the power plant, a vibration expert can diagnose the system and offer online support when needed.

Venda Nova II, Portugal

Goldisthal, Germany



HyCon vibration diagnosis system

This remote diagnosis service can be especially helpful during the tight schedule of a commissioning process. A good example is the beginning of operation at the Goldisthal pumped storage plant in Germany. Here, vibration experts from the Voith Siemens Hydro Corporate Technology Center supported commissioning and guarantee testing from Heidenheim.
The HyCon vibration diagnosis system was installed along an existing vibration monitoring system. It was used for a synchronous unit as well as for a variable speed machine.

With its high-resolution measurement data, the system was able to separate multiple influences on the vibration behavior of the units and to provide important information for evaluation and interpretation. HyCon vibration diagnosis has also been used to support the commissioning process of two new machines at the Portuguese Venda Nova II pumped storage plant.

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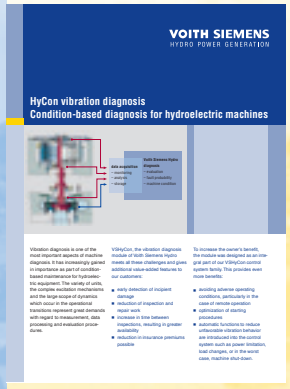

Detailed information is provided in our brochure: HyCon vibration diagnosis – condition-based diagnosis for hydroelectric machines, t3309 e.

Bussolengo and Chievo: Rehabilitation for green energy

Detail of the historical building of the Chievo power plant.

Inside the Chievo power house.

Early this summer, Voith Siemens Hydro, Italy successfully completed the modernization of two hydro power plants for Enel Power of Italy. This upgrade now gives the operator the chance to take part in the state-run incentive scheme which encourages the use of renewable energy.

Fit for Green Certificates

The output increase and modernization has been a big step forward for the operators on the liberalized energy market in Italy. Following the overhaul, Enel can apply for Green Certificates and earn additional revenue.

The Green Certificate earnings system was launched by the Italian government in 2001 as part of the Kyoto resolutions. Since the beginning of 2002 all major power producers and importers have been obliged to generate or purchase 2% of their energy, exceeding 100 GWh, from renewables.

Power plant operators like Enel Power, whose plants were installed after April 1, 1999, or have been put back into service following plant extension, replacement or reactivation since then, can apply for and trade in Green Certificates. One hundred MWh of generated energy is allocated to each Green Certificate. It applies to the year in which it was issued and continues for a period of eight years.

Through this period, the certificates can either be traded through bilateral agreements or on the Green Certificate Exchange itself. In this way, Green Certificates in Italy both promote the generation of electricity from renewables and allow the producers of power from renewables to achieve extra income in addition to the earnings on the power itself.

Output increased

The Bussolengo and Chievo plants on the Adige River in the province of Verona have been in operation since the 1940s. The two largest hydro power plants of the region with maximum 40 and 25 meter heads form part of the hydro power generation system near Ala. After the upgrade, the Bussolengo and Chievo turbines now generate 17.5 MW and 10.5 MW respectively. Together, both plants generate some 550 GWh of power a year.

In 2003, the contract for upgrading three three-meter Francis turbines was awarded – one that was handled as part of a state-run promotional program. The engineers were able to complete the plant assembly one month ahead of schedule. The units were put into commercial operation following completion of the dry run tests in May.

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Adige River, Verona, Italy

Inside the Bussolengo power house.

New runner for Austria's largest Kaplan power plant

Voith Siemens Hydro, St. Pölten, in consortium with Andritz, has been awarded the complete rehabilitation of the 40 year old Aschach power station on the Danube River.

The station opened a 40 km stretch of the Danube between Jochenstein and Aschach for power generation and improvement of navigation in this very narrow part of the river valley. Power generation efficiency is enhanced by the high head and the high winter percentage of annual energy (almost 40%). The original turbines are still the largest in Austria.

Rehabilitation works include the supply of four new Kaplan runners with an increased diameter of 8.6 m, and new spherical discharge rings, as well as the refurbishment of the distributor, changing the grease lubricated wicket gate bearings to maintenance-free bearings. A special challenge for the runner assembly is maintaining the original bottom ring with its existing diameter.

The runner blade assembly is accomplished inside the pit by means of a special blade assembly opening in the embedded discharge ring. The outage time is extremely tight, only six months, including commissioning. The first unit will be delivered in September 2006, with one runner following each successive year.

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Inside the Aschach power house.

A new pumped storage station for Portugal

Following a successful 30-day test period, the Portuguese Venda Nova II pumped storage station began supplying electricity in September 2005.

Assembly of the support ring for the thrust bearing segments.

In north-eastern Portugal, some 40 kilometers north of Braga on the Rabagão River, the Venda Nova II station shares an existing reservoir with four other hydroelectric power stations. Apart from building a pressure tunnel approximately four kilometers long and an underwater pressure tunnel 1.5 kilometers long, no other intervention in the landscape was necessary during the construction of this underground hydroelectric plant.

Voith Siemens Hydro received the order in April 2000 to supply two 92-MW units, comprising two reversible pump-turbine and motor-generator sets, spherical valves and other mechanical, electrical and electro-mechanical equipment.

Although 20% of Portugal's energy needs are already being met by hydroelectric power, the country wants to obtain an additional 19% of its energy from renewable sources by 2010, and is looking to wind power to help achieve this. The pumped storage station will play an important role in achieving this goal, as it is able to deliver its energy to the grid at extremely short notice, and will compensate for the fluctuating output of wind-generated energy.

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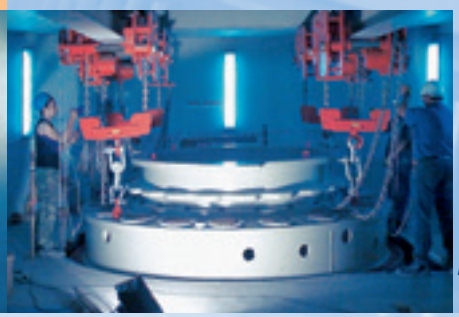

Lowering the power unit

Modernization continues at Exelon's Conowingo power station

The Conowingo plant is located on the Susquehanna River in Northern Maryland, USA, and operated by the Susquehanna Electric Company, a subsidiary of Exelon. It has been producing electric power to the transmission system since it first began commercial operation in 1928.

During an inspection on one of the generating units, engineers at the plant discovered serious problems. in the generator stator.

In early 2005, a fast-track procurement process was initiated to supply and install a complete new stator. It brought together the experience and resources of three Voith Siemens Hydro operating units in order to meet a demanding delivery schedule by the end of 2005.

With a local manufacturing facility in York, PA, Voith Siemens Hydro was able to confidently deliver on the tight schedule commitments. The stator frame was manufactured in the York facility.

Starting with a joint engineering effort between the operating units in USA, Canada, and Brazil, and finishing with a combined field operations team from York and Mississauga, Voith Siemens Hydro was able to design and deliver equipment to the site in record time.

The success of the project is credited to the cooperation and dedication of the engineers and staff at each of the operating units to insure customer satisfaction in quality and schedule commitment.

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An important visit in São Paulo, Brazil

The Brazilian Minister of Mines and Energy, Silas Rondeau Cavalcante Silva, visited the Voith Siemens Hydro installations in São Paulo, on August 31st for the first time. After a meeting with the chief officers of the company and Dr. Hubert Lienhard, President and CEO, he was enthusiastic about what he saw.

Silas Rondeau (middle) during his visit with his hosts from Voith Siemens Hydro.

"I am impressed by Voith Siemens Hydro's vertical production capacity, from casting to assembly and final production", stated Silas Rondeau.

The Minister was accompanied by the advisor Ivo Costa and the former Minister of Communications, Fernando César Mesquita (Sarney administration). The delegation learned about the manufacturing process for actual projects, including a Francis turbine, which will be exported to India's Omkareshwar project and a Kaplan runner, which will equip the Peixe Angical hydro power plant in the Brazilian state of Tocantins.

Financial director Heinz Herrmann was pleased with the opportunity of dialogue between the government and the business community and stated that learning about Voith Siemens Hydro's activities in Brazil was useful to the government.

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New Chairman of Voith Siemens Hydro, Brazil

Effective September 30, 2005, Osvaldo San Martin has assumed the position of Chairman of the Board of Voith Siemens Hydro, Brazil.

Osvaldo San Martin, new Chairman of the Board of Voith Siemens Hydro, Brazil.

He succeeds Julio Oscar Fenner, who left the Voith Siemens Hydro Management Board of São Paulo to assume other responsibilities.

Osvaldo San Martin previously served in Voith's paper division in various functions for over 26 years and was a Member of the Board of Voith Paper in São Paulo before joining Voith Siemens Hydro.

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Another milestone for electricity production in Sanxia

The spotlight was once again focused on China's Sanxia hydro power station with a formal ceremony on September 16, 2005, marking the start of commercial operation of 14 generating units in the Left Bank Power House.

The consortium of Voith Siemens Hydro and General Electric supplied six turbine generator units for the power station. An additional order for the supply of excitation systems for all 14 units was given to Voith Siemens Hydro in 2000.

The Sanxia systems represent the largest and most powerful static excitation systems ever designed and built for a hydro power plant. (see also our technical article on Voith Siemens Hydro's Thyricon systems, p. 7-8).

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Sales are on the upswing

Very good performance could be registered regarding Voith Siemens Hydro's Fiscal Year 2004/2005 performance. Sales have risen to € 594 million. Final order intake is at € 625 million. The future outlook remains positive, with expected stimulation of all markets during fiscal year 2005/2006.

Once more, China represents a regional focus of business – Voith Siemens Hydro has been awarded three projects in this market. Additional projects were won in Romania, North America, the Dominican Republic and Africa: Here Voith Siemens Hydro will provide the complete electro-mechanical equipment for Ethiopia's Gilgel Gibe II project.

The geographic range of the orders is the positive result of Voith Siemens Hydro's successful global positioning in all countries important to the hydro business.

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There is no future without the past

Voith Francis Runner from 1939

Kindly supported by the German Museum.

When, like the writers of this issue of HyPower, you are keenly focused on innovation, technological milestones and the future of energy production, an examination of our industry's history can provide a very useful way of putting it all into perspective.

And what better way of getting a feeling for the past than visiting one of the many museums that specialize in displaying and preserving the valuable artifacts of our past.

The so-called German Museum (Deutsches Museum) in Munich has particular relevance to Germany and to the industry overall, since its founder, Oskar von Miller, was also an important pioneer in the field of hydro power.

His engineering office was responsible for the construction of the Walchensee hydroelectric power station nearby Munich, for example, which opened in 1924 and until today operates as a peak-load power plant for the Bavarian electricity network and for the German Federal Railway.

It might not surprise you to learn that Voith AG and Voith Siemens Hydro helped to establish the museum's hydro engineering section, as well as contributed to the latest "Kultur und Technik" (Culture and Technology) magazine that reports on water issues, including an overview on dam construction from 3000 a. t. up to-date and hydro power stations from Oskar von Miller to Three Gorges. (http://www.deutsches-museum.de/bildung/veroeff/zeit.htm)

The permanent hydroelectric power station exhibit contains a cross-section model of a run-of-river power station with a Kaplan turbine and generator. In addition to a number of historic turbines, there are informative working models and originals artifacts of Francis, Pelton and Kaplan turbines, as commonly installed today.

Visitors can glean in-depth information about the hydrological cycle, the distribution and consumption of water, the protection of water resources and the history of hydro engineering. In addition to presentations on the various uses of water, the exhibition explores the key issues of river and waterway engineering and hydro power.

For more information:
www.deutschesmuseum.de

Francis Spiral turbine, 1952. The model shows the arrangement of a Francis turbine and the associated generator in a hydro power station. Based on an original of Voith Heidenheim.

Focus on history

Energy Museum of São Paulo.

Governor Geraldo Alckmin (middle) at the opening ceremony.

Solidarity with the past

Because Voith Siemens Hydro has strong roots not only in Brazil's economy but also in its history, Voith Siemens Hydro Brazil also sponsored the restoration of the historical building that houses the Energy Museum of São Paulo and the Energy and Sanitation Historical Heritage Foundation.

The building is located in the old quarter of the capital of São Paulo and dates back to the 19th Century. It is known as "Santos Dumont Mansion" and belonged to the family of the Brazilian aviator, Santos Dumont.

The Energy Museum of São Paulo, which was opened by the governor of the state, Geraldo Alckmin, focuses on the development of energy in Brazil, its history, innovations and research. The new museum will help to preserve more than a hundred years of history. Its collection is presented to the public in various themed exhibitions. Courses will be held and research will be conducted in partnership with universities from all over the world.

For more information:
www.museudaenergia.org.br

The Electric Power Historical Museum in Yokohama

Japan can also look back on a long history of hydro power. The first 400-horsepower hydro power station was built more than 110 years ago in 1890, to provide electricity for mining and lighting. Between 1900 and 1930, many hydro generating units, including Voith turbines and Siemens generators, were imported from Europe and the United States and installed in various places in Japan.

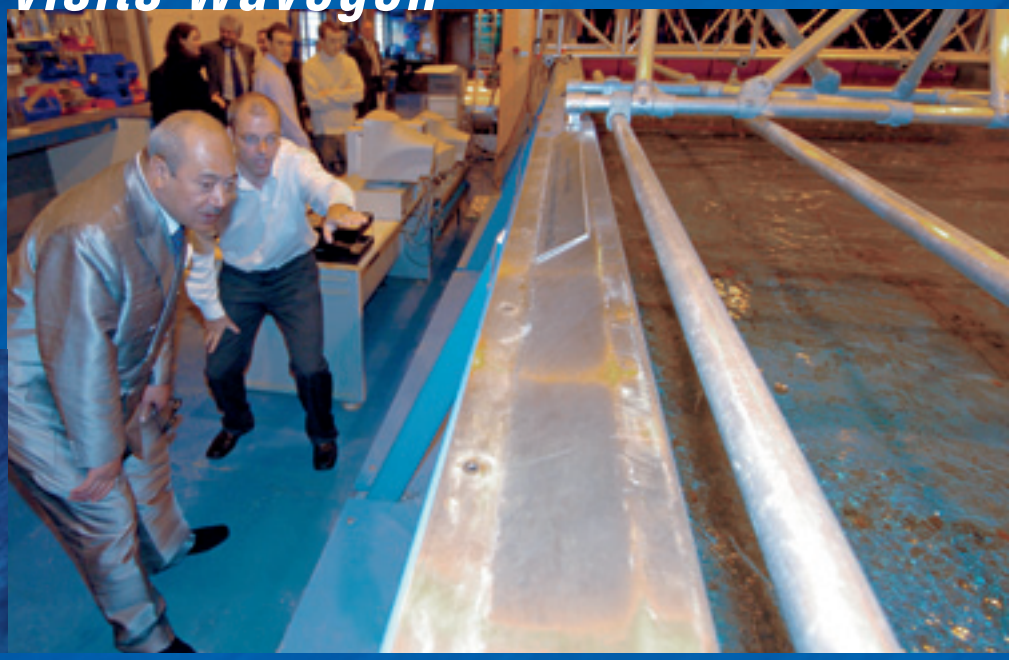
Many of the units installed during this period have been replaced with new equipment. The Electric Power Historical Museum in Yokohama, established by Tokyo Electric Power Company, provides great insight into some of the historical devices.

A wide variety of exhibits can be seen in the museum, covering topics such as the invention of static electricity, the development of hydro, thermal and nuclear power, and electricity distribution systems. In the "Hydro Power Generation Zone", prototypes of Voith Siemens Hydro turbines and generators are exhibited as monuments to hydro power generation.

For more information:
www.tepco.co.jp/rd/shiryokane/index-e.html

39 MW Voith Francis turbine and generator unit of Shinanogawa power station displayed as cross sectional view.

Prince of Tonga visits Wavegen



The Crown Prince of Tonga talks to Wavegen's Project Manager Ben Yeats about the company's tank testing facility.

His Royal Highness, the Crown Prince of Tonga, spent two days in Scotland talking to Inverness based wave energy specialist Wavegen about the opportunities for utilizing Wavegen's technology in the Pacific Kingdom.

Wavegen is the owner and operator of the world's first commercial-scale, grid-connected wave power station, the LIMPET plant on the island of Islay. The tour began with a visit to Wavegen's offices and wave tank testing facility. The following day, the group flew to Islay to visit Wavegen's LIMPET.

As well as being first in line to the throne, His Royal Highness, the Crown Prince Tupouto'a is the owner and chairman of the Shoreline Group, the Kingdom of Tonga's electricity supplier. Along with Soane Ramamlal, the group's chief executive, and Peter Goldstern, its development director, he is eager to find ways of reducing household electricity bills across Tonga.

Wavegen's team is now waiting to hear from the visitors. If they believe wave energy is a suitable solution to Tonga's rising energy costs, the next step hopefully will be for Wavegen to conduct feasibility studies in order to identify potential locations for development and to assess the wave energy resource and the potential output.

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Events 2005

Simpase, São Paulo, Brazil

Waterpower, Austin, Texas

Fuel and Energy Fair, Kiev, Ukraine

An outreach effort was created over the year to additionally focus on communication with customers, partners and engineers within the industry events.

Voith Siemens Hydro São Paulo – besides a series of events from CIGRE in Ciudad des Leste, Simpase in São Paulo to Expoman in Belo Horizonte – most prominently participated in the Brazilian energy sector entities' event in October in Curitiba, Paraná, at the 18th SNPTEE (National Seminar for Electric Energy Production and Transmission).

Voith Siemens Hydro was proud to be an active participant in Waterpower XIV, Austin, Texas in July. Also, the participation in a DSI Turkey's event, in a fair in Kiev, Ukraine, and in Hydro 2005, Villach, Austria, offered wonderful opportunities to spend time with important customers and industry professionals, during company-based cultural events.

DSI, Turkey

Fuel and Energy Complex of Ukraine was the third international forum for the Ukraine. The fair took place on September 27-30, 2005 and its organizers included the Ministry of Fuel and Energy of Ukraine and the International Exhibition Centre in Kiev.

During the second day, a seminar presenting the hydroelectric potential of Ukraine was held. Plans for modernization of existing as well as construction of new hydro power plants were discussed.

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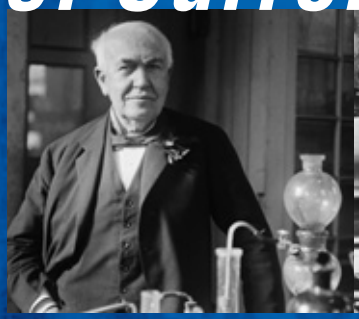
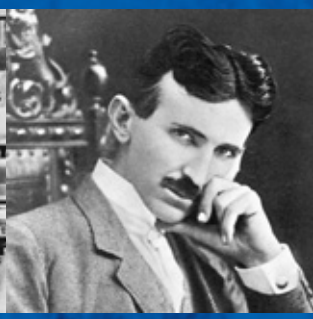
Essay

The War of Currents



Thomas Alva Edison (1847-1931), was a prolific inventor who was issued over 1,000 patents over his lifetime.

George Westinghouse (1846-1914), American industrialist and inventor.



Nikola Tesla (1857-1943), American inventor.

When advances are made in science and technology, there is often rivalry between different systems. One example is the veritable contest of giants that broke out toward the end of the penultimate century as a result of two different developmental approaches. It went down in technological history as the "War of Currents".

The opposing camps were based around two brilliant minds of the time. On one side, the outstanding inventor, Thomas Alva Edison, and on the other, the no less audacious visionary and industrial magnate, George Westinghouse.

The dispute concerning the system used for supplying the world with electricity had begun some time previously, but historians agree that the final round of the contest, fought with unparalleled tenacity, was in spring of 1890 on the banks of the Niagara.

The trigger was a competition initiated by the New York financial industry. At the time, it was clear to financiers and experts that the immense power of the Niagara River at the Canadian border should be used for more than simply driving machines on its banks. But no-one was able to transport the current generated by the river economically and without enormous output losses. An award to the tune of 100,000 dollars was thus offered to the person able to fulfill this task. Edison was an advocate of direct current, while Westinghouse believed in alternating current.

His conviction had been fundamentally defined by a young inventor from the Old World. Serbian-born Nikola Tesla stepped onto American soil in June 1884. Four years later, he gave a lecture to an audience of experts that made him world-famous. In it, he unveiled the sophisticated design of his alternating current motor operated without wear or mechanical friction and requiring very little maintenance. Present in the audience was George Westinghouse, who was impressed by what Tesla had to say.

This machine was exactly what Westinghouse lacked in his current system. He wanted not only to power lighting for domestic homes, but also to supply power to entire industrial plants. Westinghouse's problem was that the principal sectors of industry were supplied with direct current exclusively. This was Edison's domain, and he and his company then organized a campaign against alternating current.

Edison asserted that high alternating currents were unavoidably dangerous. He attempted to introduce legislation to restrict transmission voltages to 800 volts, but was unsuccessful. He then engaged engineer Harold P. Brown, who dramatically exhibited animals in public in order to kill them with the highly dangerous alternating current before a crowd.

The conflict took an even more absurd turn when Westinghouse made an ingenious coup in 1893. He convinced the organizers of the World's Fair in Chicago that his alternating current system would enable him to bathe the city in a sea of light as had never been seen before and was awarded the contract.

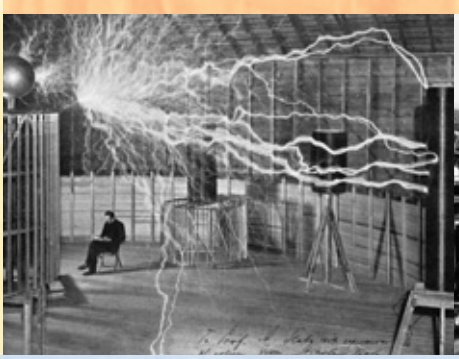
But Edison was not about to give up. He prohibited the use of his light bulbs in this event. Within a period of 20 weeks, Westinghouse had to set up his own production facilities and manufactured some 250,000 bulbs. The light they produced was so amazing that almost 30 million people came to Chicago to see Westinghouse's huge carpet of light.

It was a triumphant victory. Even the Niagara commission was impressed. Only alternating current could be used to harness the power of the Falls. Westinghouse received the prize money and the contract to design the power plant. Nikola Tesla developed the most powerful generators and turbines the world had ever seen.

The big event came in 1895: The power plant on the Niagara opened – a break-through in technological history. Ten turbines with a total output of 50,000 horsepower drove huge alternating current dynamos. The current was stepped up ten times, transported to Buffalo, 36 kilometers away, and again stepped down to a lower voltage.

A memorable anecdote for Voith: In 1903, Voith was awarded the contract to build four spiral twin turbines each with an output of 8,826 kW. Turbines from Heidenheim were required for expansion and output increases during the following year!

Generating artificial lighting in Nikola Tesla's laboratory.



The General Electric Tower of Light display at the Columbian Exposition in Chicago, Illinois, 1893.

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