HYDROMATRIX®

Innovative hydropower solutions

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What is HYDROMATRIX®?

The HYDROMATRIX® concept consists of a factory assembled “grid” of modules containing small propeller turbine-generator units, that can be grouped flexibly in various power plant arrangements. HYDROMATRIX® plants can be installed at existing dam and gate structures as well as at greenfield projects.

HYDROMATRIX® modules are shipped in pre-assembled condition to the power plant site where they are installed into the existing water passage. The turbine-generator (TG) units are switched on and off using hydraulically operated sliding gates.

The design of the modules allows the lifting or removal from the operating position like a sliding gate. This enables the passage of flood water and simplifies inspection and maintenance work on the TG-units.

This innovative concept* for hydraulic energy generation was further developed by ANDRITZ HYDRO and combines the advantages of proven ANDRITZ HYDRO TG technology with economical and time saving installation.

Projects that are not economically feasible with conventional TG designs can now be profitably developed by using the HYDROMATRIX® approach.

Several ground-breaking reference installations, each using the HYDROMATRIX® concept under different site-specific conditions, have been operating successfully for more than 10 years. They are a testimony to the viability of this innovative approach for low-head hydropower.

In 2010 ANDRITZ HYDRO received the Austrian State Prize for Environmental and Energy Technology for its HYDROMATRIX® concept.

*ANDRITZ HYDRO holds several patents pertaining to specific features of the HYDROMATRIX® concept.

Why HYDROMATRIX®?

HYDROMATRIX® plants offer several advantages where conventional hydropower designs cannot provide suitable solutions:

Use at existing structures

HYDROMATRIX® technology enables customers to tap into the unused hydropower potential of intake towers, unused ship locks, canal weirs and navigation and irrigation dams by using these existing structures as a profitable and renewable energy resource.

Flexibility in arranging the small TG-units and associated electromechanical equipment allows integration of HYDROMATRIX® plants in existing structures that fulfil the basic application criteria.

High profitability

HYDROMATRIX® turbines can operate with only minimal tailrace submergence. Deep excavation and other costly civil work can be avoided, thus leading to significant cost savings. State-of-the-art hydraulic runner design and generator technology guarantee highest possible energy generation through high levels of hydraulic and electrical efficiency. Together with the high plant availability resulting from the large number of generating units these factors contribute to the high profitability of the HYDROMATRIX® solution.

Environmental benefits

The use of existing structures avoids additional land use. The already established flood plains remain unchanged, thus minimizing the impact on valuable agricultural land or residential areas.

HYDROMATRIX® plant designs can also be easily integrated into urban areas, which have stringent aesthetic requirements.

Short project schedule

Since only minor civil work is required to adapt existing structures, construction schedules are significantly shorter than those of conventional large hydropower plants. Additional time savings during installation and commissioning are achieved by using pre-assembled and factory tested core elements for the HYDROMATRIX® plant.

Easy operation and maintenance

The standardized, robust HYDROMATRIX® design featuring unregulated turbines and synchronous generators makes it easy to integrate and operate the plants within the existing power grid.

HYDROMATRIX® plants do not require complicated maintenance work for extended periods apart from changing lubricants and filters, depending on operating hours.

Since every TG-unit can be easily removed from its operating position, inspections are quick, safe and straightforward. Moreover they have no impact on the operation of the other TG-units. The small unit size allows overhauls to be performed in a workshop.

Application criteria

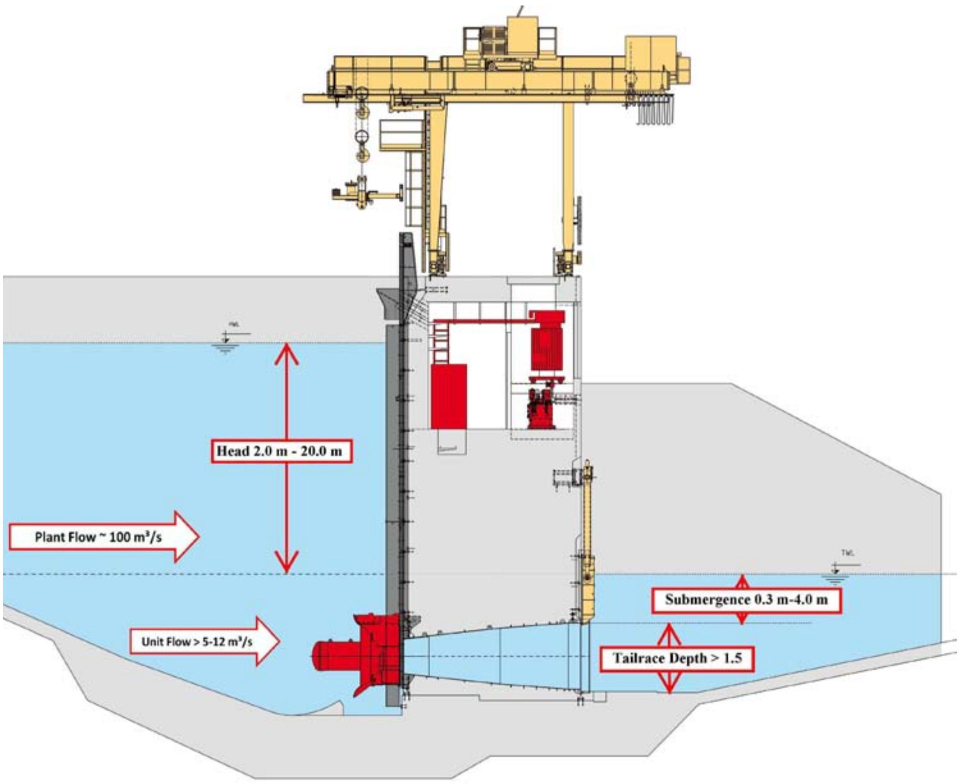
The following criteria should be met in order to achieve technically and economically feasible HYDROMATRIX® applications:

Available discharge of approx. 100 m³/s (3,500 cfs)
Depending on the head, the discharge of a single TG-unit ranges between 5 and 12 m³/s. As the TG-units are unregulated as many units as possible should be installed. This allows adjustment to varying flows and minimizes the impact of balance-of-plant equipment cost. Sites with discharges of less than 50 m³/s should feature higher heads in order to ensure economic operation.

Head between 2 m - 20 m (6.5 - 65 feet)
HYDROMATRIX® plants are mostly used in low head applications. Most reference plants have been proven to be economical at rated gross heads of about 5.0 m. In exceptional cases with higher heads up to 20 m,even a smaller number of units can result in an economically attractive plant setup.

Tailrace depth:
In order to install one row of TG-units a minimum water depth of 1.5 m measured from the sill of the tailrace is required. If tail race depth is higher, two row plant arrangements may be possible. This allows larger plant capacity with low space requirements.

Submergence:
Apart of the tailrace depth, turbine hydraulics requires additional submergence depending on the available head and discharge. At heads between 2.0 m-12.0 m submergence should be about 0.3 m-2.0 m. At higher heads the required submergence may be up to 4.0 m.



Civil structures suitable for HYDROMATRIX® module(s)
Existing civil structures should fulfil the criteria for minimum discharge and submergence. HYDROMATRIX® plants with new civil structures offer an economic alternative if site specific conditions require more expensive civil work for a conventional hydropower plant.

Utility grid connection
Grid operating authorities issue terms and conditions (grid codes) to regulate the physical connection between the utility grid and the power plant. ANDRITZ HYDRO offers technical assistance in the development phase to assess those codes and to work out technical solutions to ensure compliance.

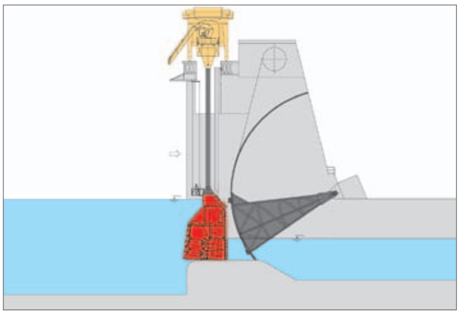
HYDROMATRIX® plants use PM-synchronous or asynchronous generators at lower medium voltage level. The output can be regulated in steps by switching single TG-units on or off.

Synchronous generators can be easily integrated into utility grids and usually do not require power factor compensation. Depending on the boundary conditions, power factor compensation equipment may be used for asynchronous generators. At larger plants, step up-transformers may feature on-load tap changers to have more flexibility for voltage control.

Application Types

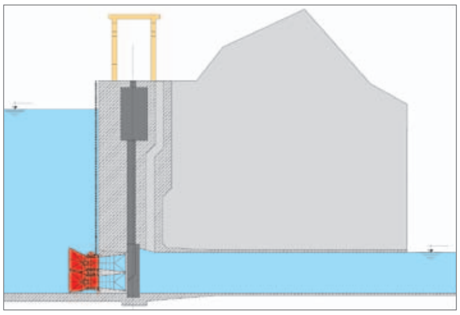
Navigation dams

Large lock and dam structures built along major rivers for navigational purposes are an ideal opportunity for HYDROMATRIX® application. Adding hydropower production to these sites can be very economical, if the existing structures allow implementation of HYDROMATRIX®.



Intake Structure

Water reservoirs or the bypass tunnels of existing hydropower plants usually feature intake structures which can be an ideal opportunity for using HYDROMATRIX® technology. In such applications operating heads of up to 20 m are feasible if sufficient submergence can be established.

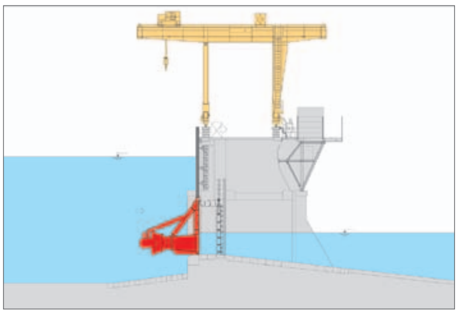


Use in new structures

Incorporating HYDROMATRIX® modules for power generation should be assessed in the planning process of new dams, weirs or other hydraulic infrastructure for irrigation or flood control. In most cases considering such a multi-purpose approach at an early stage can offer significant additional benefits and an improved economic framework.

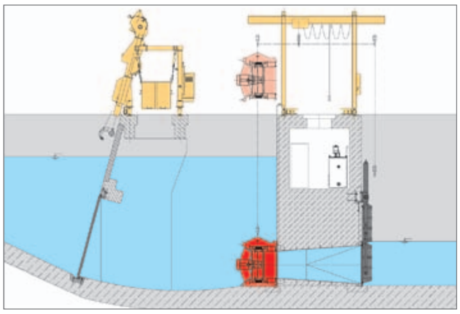
Irrigation dams

Constant flow rates and relatively small head fluctuations make irrigation structures ideal for HYDROMATRIX® applications. Thanks to the modular concept HYDROMATRIX® power generation equipment can be fitted at various dam structures with suitable tailrace submergence.



Canal weirs and unused ship locks

Canals or navigation structures frequently have weirs or unused lock structures that have sufficient head differential for the installation of HYDROMATRIX® modules for power generation. If flood discharge capability is vital, the modules can be lifted out of the water or the HYDROMATRIX® power plant can be designed to allow overtopping during flood conditions.



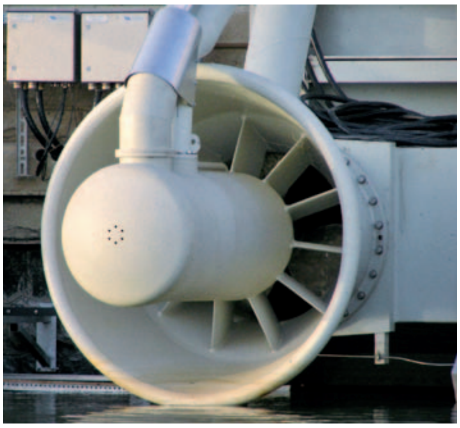
Jebel Aulia

The Jebel Aulia dam is located on the White Nile. The dam was originally built for irrigation of the adjacent agricultural land and features 50 discharge openings fitted with Stoney Roller gates.

The HYDROMATRIX® powerplant consists of 40 modules, each equipped with two TG-units in one row. The modules and 80 associated TG-units were installed in front of the existing discharge openings and can be lifted for maintenance purposes by a newly installed gantry crane. The electrical and mechanical auxiliary equipment was installed inside containers placed on platforms along the downstream side of the dam.

ANDRITZ HYDRO supplied and delivered the entire electromechanical equipment which was installed by the customer under the supervision of ANDRITZ HYDRO personnel.

Since it was possible to use the existing gate slot structures, very little civil construction work was required. The resulting cost savings proved to be one of the decisive factors for the realization of this project.



Technical data:

Plant capacity:	30.4 MW
Head:	5.5 m (18 feet)
Speed:	375 rpm
Unit Output:	380 kW
Runner diameter:	1,120 mm (44.1 inches)
Number of units:	80
Average yearly production:	116.4 GWh

Agonitz

Prior to modernization and upgrading of the existing Agonitz plant on the upper reaches of the Steyr river in Austria, ANDRITZ HYDRO had the opportunity to conduct prototype tests with a HYDROMATRIX® as well as with its newly developed StrafloMatrix™.

Following the favorable results obtained in these tests, the Austrian utility company ENERGIE AG decided to join forces with ANDRITZ HYDRO and to equip the new power plant with two new turbines. In addition to a conventional Kaplan turbine the world's first commercially operating StrafloMatrix™ was installed. As part of a development agreement the StrafloMatrix™ is being assessed and optimized over an extended five-year test period under real time grid conditions.

Main activities in the Agonitz plant upgrade:

- Construction of a new powerhouse suitable for two units with plant discharge increased from 20 m³/s to 45 m³/s.
- Adaptation of intake gate for StrafloMatrix™.
- Dredging of tailrace to increase head by 1.3 m.
- Improvement of flood safety.
- Construction of new fish ladder consisting of natural riverbed and vertical-slot fish bypass.

The special combination of the unregulated StrafloMatrix™ with a regulated vertical Kaplan unit allows operation of both units while maintaining a constant upper pool level. The StrafloMatrix™ was successfully put in operation in 2003 and is available for demonstrations to potential customers and interested parties from all over the world.

Technical data:

Plant capacity (incl. Kaplan turbine):	3.1 MW
Head:	8.5 m (27.8 feet)
Speed:	428.6 rpm
StrafloMatrix™ Output:	700 kW
Runner diameter:	1,120 mm (44.1 inches)
Number of units:	1
Average yearly production (incl. Kaplan turbine):	15.8 GWh

Nussdorf

The Nussdorf HYDROMATRIX® plant is located downstream of the Schemerl Weir at the intake of the Danube Canal at Nussdorf, an outlying district of the city of Vienna, Austria. The canal and the weir with its two radial gates are part of the city's flood protection system.

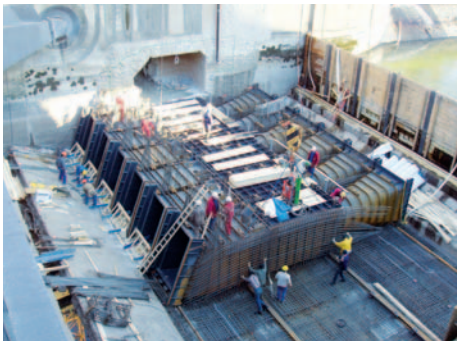
Apart from the requirement to enable discharge of water at all times another major aspect of the project was the need to integrate the new plant carefully into the existing ensemble of the Nussdorf Weir and adjacent building designed by the famous Jugendstil architect, Otto Wagner.

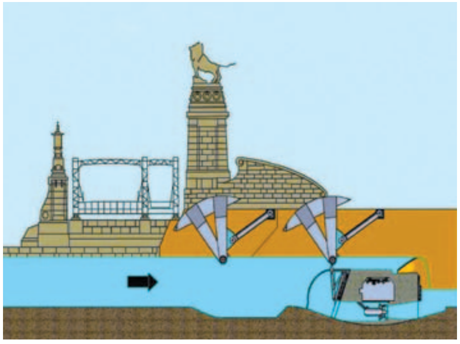
The small-scale hydropower plant consists of a 30 m long, approx.12 m wide and 7 m high hollow-body weir housing twelve TG- units, with spillway gates mounted on top of the weir, and an operation building adjacent to the weir structure.

Due to the innovative plant design, the hydraulic equipment for the intake and draft tube gates could be placed in an underground gallery, which is also used to remove the TG-units for maintenance purposes.

Power cables are routed from the generators to the switchgear housed inside the plant operation building on the left bank of the canal. An arc-shaped intake trashrack, with an accompanying trashrack cleaning machine, is located in front of the new weir structure. It continuously removes the debris that floats to the surface and is discharged over the spillway.

The project was executed by a consortium of ANDRITZ HYDRO, Porr Technobau, and Verbundplan as consortium leader. After a record construction time of only one year, Nussdorf successfully went into operation in 2005.





Technical data:

Plant capacity:	6.5 MW
Head:	5.6 m (18.4 feet)
Speed:	336.7 rpm
Unit Output:	545.7 kW
Runner diameter:	1,320 mm (~52 inches)
Number of units:	12
Average yearly production:	24.7 GWh

Chievo Dam

In Verona's district of Chievo a dam and adjacent ship lock were built in the 19th century on the Adige river to establish the Camuzzoni canal. The abandoned ship lock downstream of the dam is owned by Consorzio Canale Camuzzoni and was modified to harvest the unused hydropower potential of the abandoned lock without compromising its flood discharge capabilities.

The core element of the Chievo dam HYDROMATRIX® plant is the steel-fabricated module, which is located at the downstream end of the lock. The bottom part is formed by five draft tubes arranged in one row. On top of the draft tubes, a submersible equipment gallery houses the hydraulic power unit and the power cables. Upstream of the module there are five StrafloMatrix™ TG-units that can be switched on and off separately by opening or closing individual draft tube gates.

The entire module can be lifted and lowered by a gantry hoist system under balanced conditions in order to evacuate the lock chamber prior to flood release.

By minimizing the amount of civil work required, the HYDROMATRIX® technology allowed the building of a hydropower plant with no negative impact on the beautiful historical site and surrounding recreational area.

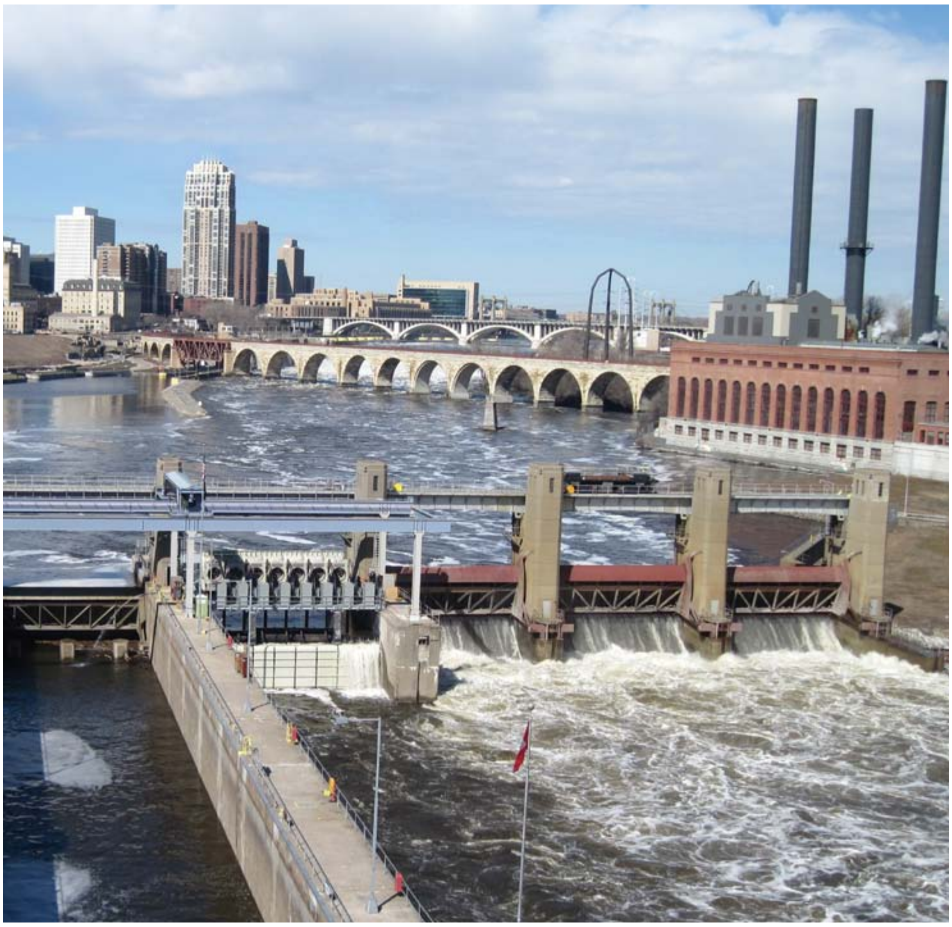
The HYDROMATRIX® plant at the Chievo dam in Verona was successfully commissioned in the fall of 2009, meeting the energy needs of around 10,000 households.

In 2010 ANDRITZ HYDRO received the Austrian State Prize for Environmental and Energy Technology for this innovative project.

Technical data:

Plant capacity:	1.35 MW
Head:	3.8 m (12.4 feet)
Speed:	250 rpm
Unit Output:	270 kW
Runner diameter:	1,320 mm (~52 inches)
Number of units:	5
Average yearly production:	12 GWh

Lower St. Anthony Falls



The lower St. Anthony Falls (LSAF) Lock and Dam are located on the Mississippi River in the city of Minneapolis, Minnesota, USA. LSAF forms part of the inland waterway navigation system and was built by the government in the 1950s. It consists of a main lock, an incomplete auxiliary lock, a dam section equipped with radial gates and a non-overflow dam.

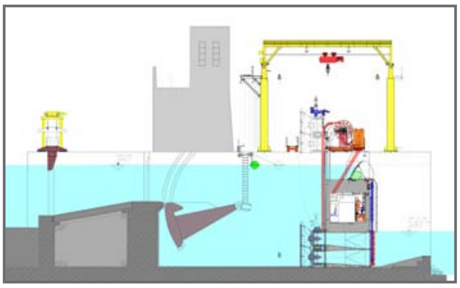
The 10 MW StrafloMatrix™ plant was planned by a private development group and installed in the existing auxiliary lock.

The core element of the plant is a newly constructed retaining wall inside the existing auxiliary lock structure. Its upstream side houses eight modules, each containing one pair of TG-units in a two row configuration. The draft tubes form an integral part of the retaining wall. Above the draft tubes there is an underground equipment gallery, which contains the generator switchgear and hydraulic power units for operation of the draft tube gates. Pneumatically operated spillway gates are installed on top of the retaining wall and used to spill smaller ice and debris. They also facilitate flood discharge.

Steel platforms are mounted across the top level of the auxiliary lock to allow installation of cable reels. When the TG-units are lifted out of the water by a newly installed overhead travelling gantry crane during maintenance or in the event of flooding, the power and control cables are automatically reeled up onto the cable reels.

The electrical power is transmitted from the generator switchgear located inside the underground gallery to the main transformer and a 13.8 kV outdoor switchyard, which is located on the right embankment on the upstream side of the dam. This is done via medium voltage cables across the runway support structure of the crane.

Site construction started in spring of 2009 with commissioning and completion of the project in December 2011.



Technical data:

Plant capacity:	10 MW
Head:	7.6 m (25 feet)
Speed:	327.3 rpm
Unit Output:	625 kW
Runner diameter:	1,320 mm (~52 inches)
Number of units:	16 (2 rows of 8)
Average yearly production:	62 GWh

Ashta I & II

The Ashta I & II Hydropower Project is located on the Drin River near the city of Shkodra in Albania and comprises two power plants of similar design. Ashta I is located next to an existing weir. It includes an intake trashrack along with a trashrack cleaning machine. The tailrace of Ashta I consists of a 6 km long canal connecting the two plants and an additional diversion channel connecting the plant with the Drin River. With the exception of the trashrack, the Ashta II plant has a similar arrangement to Ashta I and its tailrace will be connected to the Drin River by a short canal.

Each power plant is equipped with forty five HYDROMATRIX® TG-units mounted at the upstream face of a concrete gravity dam structure. The TG-units are arranged in one row in front of the dam structure and can be raised individually for servicing purposes. The accompanying draft tubes are embedded in the newly constructed dam structure. The hydraulic and electrical equipment is installed in an underground gallery located above the draft tubes.

Water flow may be stopped separately for each machine by a sliding gate on the downstream face of the dam structure. In the event of gate maintenance, the same crane as for lifting the TG-units is used. In late 2012 Astha I&II were sucessfully commisioned and put into operation.

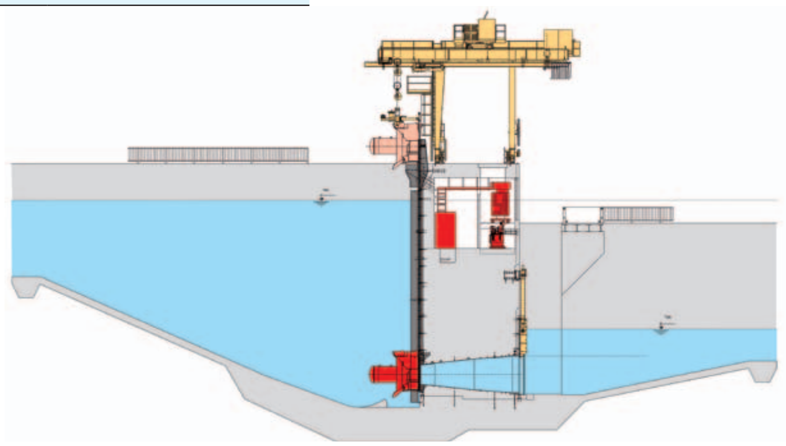
Technical data:

Ashta I

Plant capacity:	24.03 MW
Head:	4.98 m (16.3 feet)
Speed:	300 rpm
Unit Output:	534 kW
Runner diameter:	1,320 mm (~52 inches)
Number of units:	45
Average yearly production:	98.5 GWh

Ashta II

Plant capacity:	45.14 MW
Head:	7.53 m (24.7 feet)
Speed:	375 rpm
Unit Output:	1,003 kW
Runner diameter:	1,320 mm (~52 inches)
Number of units:	45
Average yearly production:	145.5 GWh

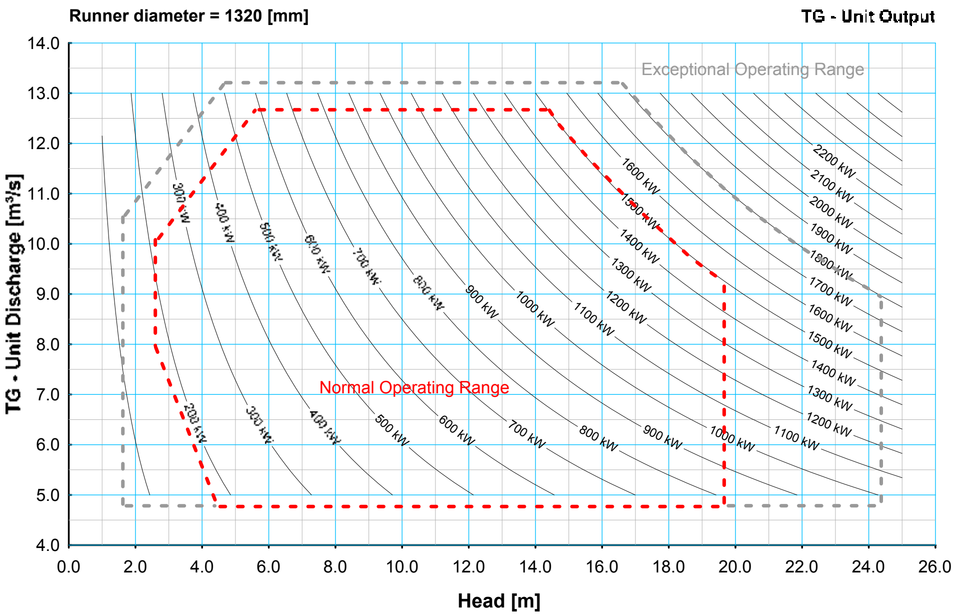


Technology and Operating Range

Hydromatrix®

HYDROMATRIX® TG-units are in use at the majority of the reference applications. The design of these axial-type propeller turbines with bulb-style generators was developed on the basis of proven conventional turbine and generator design. It was further improved by applying state of the art permanent magnet technology for the generator rotors.

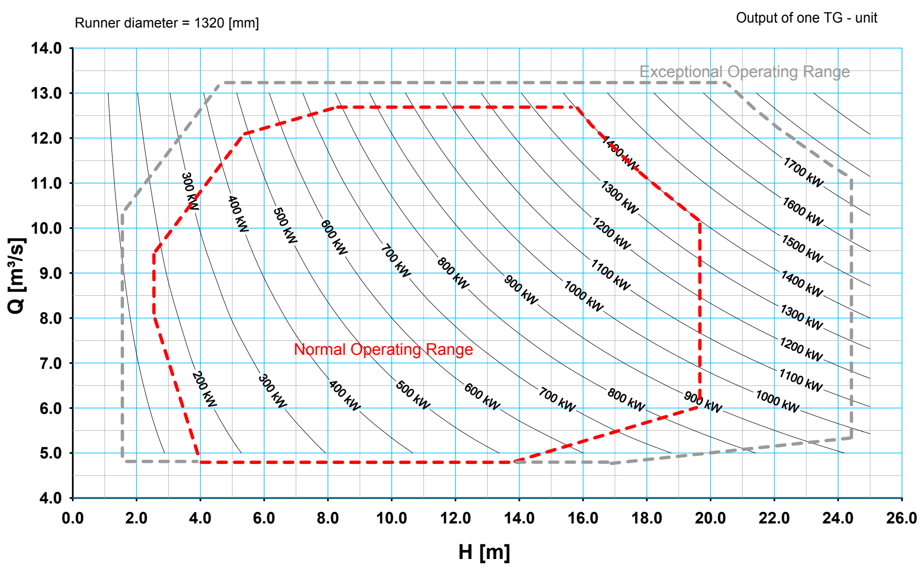
Equipped with sump-lubricated roller bearings and mechanical face seals, these TG-units have minimal maintenance requirements and guarantee reliable operation throughout their service life. ANDRITZ HYDRO offers asynchronous and synchronous generators in both low and high-voltage.



Operating Range – HYDROMATRIX®

StrafloMatrix™

StrafloMatrix™ is a special design for applications with limited space or restrictions with regards to the maximum module weight. This design places the generator directly on the periphery of the turbine runner, which results in a very compact arrangement and makes StrafloMatrix™ units 50% shorter and weighing 35% less than HYDROMATRIX® units.



Operating Range – StrafloMatrix™

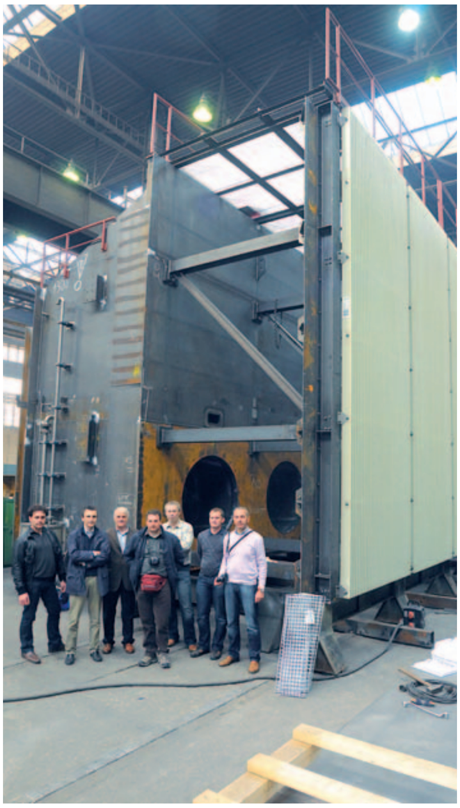
The unit outputs indicated on the charts consider the typical hydraulic and electric plant losses (trashrack, friction, cabling, generator transformer, etc.). The charts are supposed to give an indication of the actual plant output which can be expected at the point of interconnection. For performance optimization a detailed hydraulic layout is usually performed.

Main characteristics:

- Straight-flow fixed propeller turbine
- Sump-lubricated roller bearings
- Mechanical Face seal
- Permanent magnet generator rotor technology

The generator rotor consists of permanent magnets arranged on the outer perimeter of the turbine runner. To achieve a watertight generator assembly, rotor and stator are filled entirely with a sealing and insulation compound. Due to friction losses in the water filled generator gap, the power output of StrafloMatrix™ units is lower than HYDROMATRIX® units.

Electromechanical Equipment



Electrical equipment

The core elements of the electrical equipment line-up are the generator switchgear and associated control and protection system. Depending on the plant arrangement, this equipment may be located inside or outside the civil engineering structure or partially integrated into the module setup. Our integrated automation system NEPTUN is used together with PLC-type control hardware to allow fully automatic and remote operation of the entire power station.

The system is completed by step-up transformers, high-voltage switchgear, and station service equipment located either in a plant operation building or close to the dam. As part of its water-to-wire competence, ANDRITZ HYDRO offers specific plant control and automation solutions including cascade and remote control capabilities for optimized plant operation.

Module steel structure

Each module consists of a rigid, steel-fabricated structure that supports one or more TG-units. The module interfaces with the civil engineering structure and also serves as a junction box for the electrical connection between TG-unit and switchgear. In most cases, rubber seals are installed along the perimeter to minimize bypass leakage. In certain applications, the module also includes steel-fabricated draft tubes with integrated control gates. The draft tube shape and geometry are optimized to achieve high plant efficiency. Depending on the plant arrangement and site conditions, trashracks, bulkheads or spillway gates may also be incorporated.

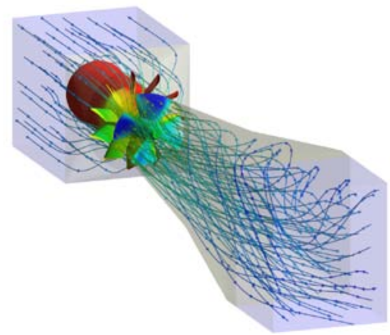
Auxiliaries

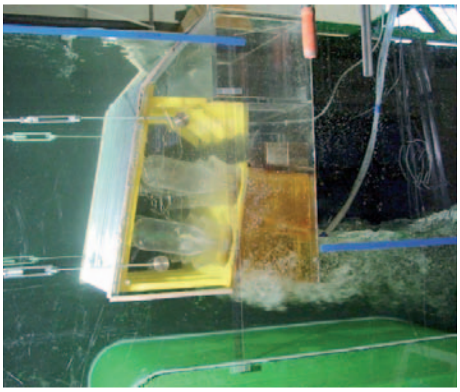
Only a few auxiliaries, such as the hydraulic power unit that actuate the draft tube gate, are required to operate a HYDROMATRIX® plant. Where there is no crane available or only a crane with insufficient capacity, a new crane including a runway can be supplied and installed. Depending on the boundary conditions, a trashrack cleaning machine and emergency diesel generator can also be provided.

R&D Competency

The hydraulic profiles used in HYDROMATRIX® and StrafloMatrix™ turbines have been developed and tested at our hydraulic laboratories using a special test rig. The achievable maximum turbine efficiency is about 92%. Using a large number of turbine units and saving on investment costs for civil construction works sufficiently compensates for the difference in energy generation output compared to conventional bulb turbines.

In addition to the hydraulic model tests, ANDRITZ HYDRO also investigates inflow conditions and hydraulic effects around the module's steel structures on a case-by-case basis in cooperation with university test laboratories. The findings gathered at these tests enable ANDRITZ HYDRO to assess and optimize the hydraulic boundary conditions at prospective locations of HYDROMATRIX® plants.

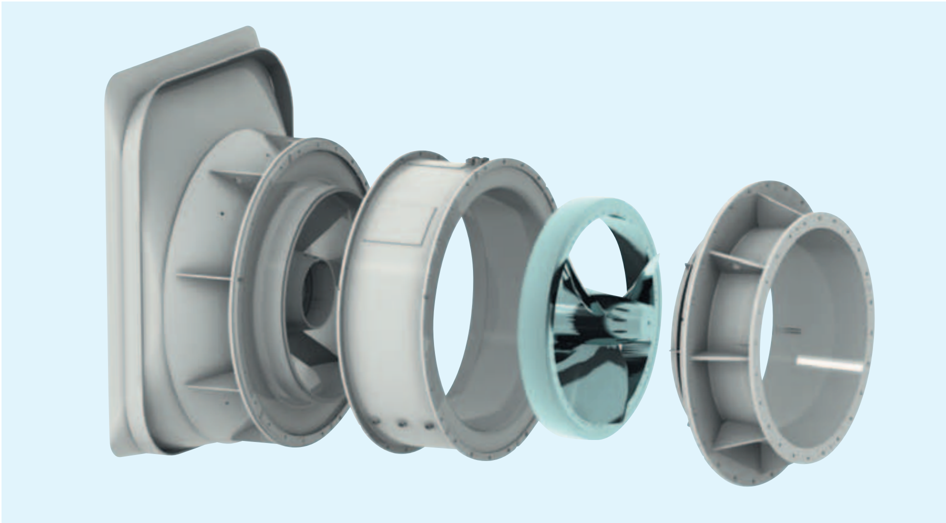




Lifecycle product support

From design and calculation of the electromechanical components, such as the hydraulic steel structures and TG-units, to the quality assurance and project management aspects of turn-key jobs, ANDRITZ HYDRO has the in-house competence for the entire electromechanical equipment range in order to develop and execute HYDROMATRIX® projects on a water-to-wire basis. This ensures that the projects are built on schedule and fulfill the performance and quality criteria guaranteed by ANDRITZ HYDRO.

A team of experienced engineers and project managers, as well as service technicians specialized in HYDROMATRIX® applications, is dedicated to assisting the customer from the early development stage onwards and remains involved throughout the life cycle of the plant. ANDRITZ HYDRO offers comprehensive training programs and maintenance support to assist the customer in his internal capacity-building process.



Further Information

Information needed for a Budget Quotation

- Top view of the existing civil engineering structure, including main dimensions and space available for HYDROMATRIX® plant equipment
- Cross-section of existing civil engineering structure, showing main dimensions, elevations, as well as headwater and tailwater levels, (nominal, minimum, maximum)
- Hydrological data (as much historical data as possible)
  - Headwater level
  - Tailwater level versus discharge
  - Discharge versus time
  - Flood discharge requirements

Content of Budget Quotation

- Preliminary technical data of HYDROMATRIX® plant, including:
  - Number of units
  - Runner diameter
  - Unit output
- Layout drawing
- Preliminary annual energy calculation
- Preliminary time schedule
- Budget price

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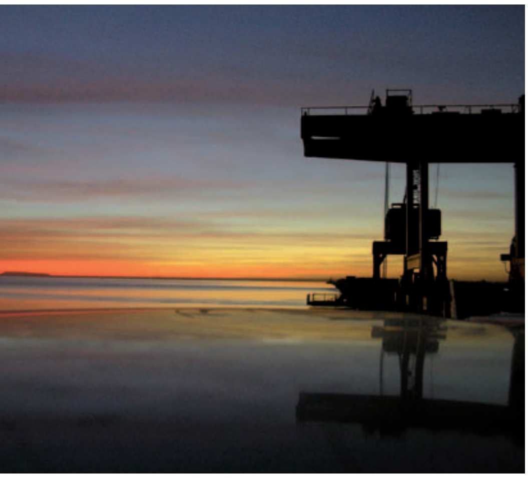

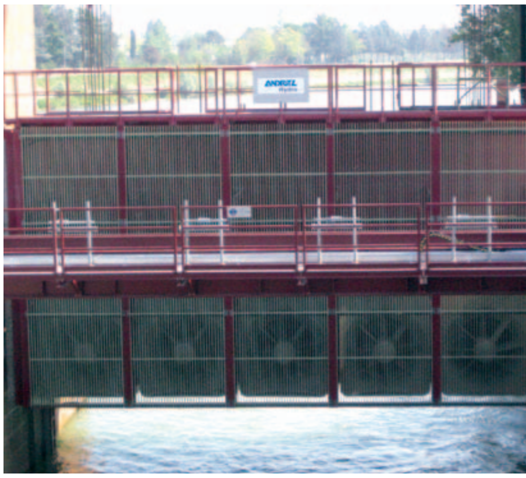


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