

HYDROMATRIX®

Jebel Aulia - Sudan



HYDROMATRIX® - Concept

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HYDROMATRIX® is a new concept of hydraulic energy generation, which has been developed by an American engineer in 1983 and further improved by ANDRITZ HYDRO.

The concept makes use of existing weir structures with no need for additional civil works. When application conditions are suitable for HYDROMATRIX®, energy can be generated within a very short time at low cost. The HYDROMATRIX® technology allows tapping the unused hydropower potential of existing drops at rivers to develop a valuable renewable energy resource. The advantages consist of proven technology and low cost installation into the existing dam structures and weirs. Since there is no civil work necessary, the HYDROMATRIX® technology enables power plant operators to develop hydroelectric power plants at extremely competitive costs with minimum impact on the environment.

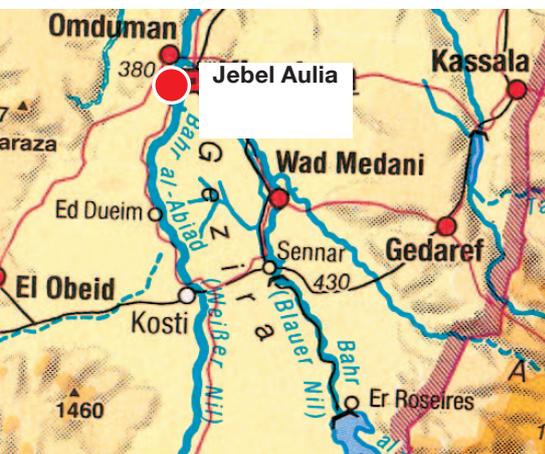
The Jebel Aulia project is a classic example for adapting an existing irrigation dam structure for hydropower generation. The Jebel Aulia dam is located on the White Nile in Sudan, about 40 km south of



Khartoum. The dam itself was built from 1933-37 for irrigation purposes and flood control. The following preconditions had to be met to allow the incorporation of HYDROMATRIX® technology:

- The dam had to withstand the changed hydrostatic loads due to the hydropower installation
- The minimum available width of the existing gate openings had to be 2.20 meters per installed Turbine-Generator Unit.
- Since the dam is also used for flood release a suitable crane or hoist arrangement had to be installed to allow lifting of the modules within the given time span to avoid the backing up of flood water.

subsequently converted into a multipurpose dam, which serves both irrigation and energy needs. The available river discharge on the White Nile at Jebel Aulia allowed the installation of 80 Turbine-Generator (TG-) units with a total plant capacity of 30.4 MW. With its generating capacity the HYDROMATRIX® power plant at Jebel Aulia is considerably contributing to the electricity generation in Sudan by means of environmentally friendly hydropower.



All the preconditions mentioned above were fulfilled and the Jebel Aulia dam was



Jebel Aulia HYDROMATRIX® Power Plant



Once the development phase of the project was successfully completed, the National Electricity Corporation (NEC), the Sudanese state owned utility, awarded ANDRITZ HYDRO with the supply contract for the electromechanical equipment. The excellent business relations between National Electricity Corporation and ANDRITZ HYDRO go back to the year 1968, when the customer ordered the equipment for the Roseires hydropower plant. The National Electricity Corporation carried out all local activities. The Jebel Aulia dam is a masonry dam and features fifty (50) discharge openings fitted with manually operated Stoney Roller gates. Originally these gates were used to regulate the flow and up-

stream water level. To implement the HYDROMATRIX® concept, forty (40) of the discharge openings were modified as follows:

- On the upstream side of each discharge opening, one power module containing two integrated Turbine-Generator units and draft tubes was installed.
- Guiding rails were mounted on the upstream surface of the dam to allow lifting and lowering of the power modules.
- The existing Stoney Roller gates were refurbished and motorized to use them for the on/off operation of the turbines. Both turbines of one module are turned on or shut off simultaneously.

The modules and Turbine-Generator units themselves were shipped to the site and pre-assembled prior to being installed into the existing water passages.

On the downstream side of the dam, the electric balance of plant equipment was installed inside standard shipping containers, which were placed onto support frames



mounted to the dam wall. Flexible power cables are connecting the generators with the switchgear containers and are further routed along the dam to a switchyard which interconnects with the Sudanese grid. A new gantry crane was installed to allow lifting and lowering of the power modules for maintenance and during flood events. When river discharges in excess of the module capacity must be passed, the HYDROMATRIX® module may be raised or removed from the operating position like a gate.

The plant was built in several lots with the first units being commissioned in 2002 and the final units becoming operational in 2005.



HYDROMATRIX®

Power Modules and TG-Units

Each power module consists of a rigid, steel-fabricated structure with integrated draft tubes. The draft tube shape and geometry are optimized to achieve high plant efficiency. In addition to the power module being a support and lifting structure for the TG-unit, it also serves as a hydraulic water passage. It interfaces with the dam's civil structure and also serves as a junction box for the electrical connection between TG-unit and switchgear. Rubber seals are installed along the perimeter to minimize bypass leakage.

Each power module is equipped with two fully submerged Turbine-Generator (TG-) units in a bulb turbine configuration featuring horizontally positioned propeller turbines. The fixed 3-bladed turbine runner is precision cast of aluminium bronze. It is directly coupled to an induction type generator with a rated voltage of 690 V. The generator housing is coupled to a distributor cone with 11 fixed stay vanes and an integrated discharge ring. The downstream flange of the distributor cone is bolted to



the power module. On the upstream side of the generator housing a flange connects with the junction box for the power cables. From the junction box the power cables are routed along the support structure of the power modules to the equipment

container. Equipped with grease-lubricated roller bearings and mechanical face seals, the TG-units have minimal maintenance requirements and guarantee reliable operation over their service life.



Electromechanical Equipment

Electrical BOP equipment

The core elements of the electrical equipment line-up are the generator switchgear and associated control and protection system.

Ten 690 V asynchronous generators are grouped in sections of 5 modules. These are fed into one generator switchgear substation and an associated 690 V/33 kV step up transformer. Each of these eight substations has its own unit control system and also includes the reactive power compensation. The switchgear and control cubicles are installed inside temperature controlled shipping containers which are placed on steel platforms along the downstream side of the dam. From the eight substations individual cables run to a 33 kV station located on the bank of the river.



For the emergency power supply a diesel generator unit is installed which acts as a backup power supply in case of loss of net-voltage for the control gates gear motors and the module crane.

The entire power plant is managed from a central plant control station. With this concept it is possible to operate each lot independently from the others. ANDRITZ HYDRO's 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 TG-units are shut on and off by opening and closing the Stoney Roller gates using direct current motors and frequency converters.



Electromechanical Equipment

Mechanical Auxiliaries



Technical data:

Unit Output:	380 kW
Voltage:	690 V
Head:	5.5 m
Speed:	375 rpm
Runner diameter:	1,120 mm
Number of units:	80
Average yearly prod.:	116.4 GWh

The new gantry crane including runway is one of the few mechanical auxiliaries required to complement the electromechanical components of the Jebel Aulia HYDROMATRIX® plant. Its purpose is to lift the forty modules for inspection, maintenance and prior to flood periods. It also allows removal of a module from its dam position.

The gantry crane is additionally used to place a movable maintenance platform on the upstream side of the dam. The maintenance platform allows all-around access to the module and Turbine-Generator units.



HYDROMATRIX®

Maintenance requirements

Since HYDROMATRIX® systems typically consist of a relatively large number of TG-units and associated equipment, the design of the components must emphasize robustness and reliability. Examples of this design approach on the mechanical side are grease-lubricated roller bearings, mechanical face seals and the omission of wicket gates, just to name a few. This design concept allows reducing the maintenance on the TG-units to periodical oil changes for the bearings.

The electric power systems generally consist of standard, industrial grade, components, which are designed to

withstand long operating cycles while having low maintenance requirements. Core components such as the generators, the switchgear and the transformers are

furnished with sensors, performance and condition monitoring equipment to allow continuous monitoring, proper diagnostics and trouble free operation.



