HYDROMATRIX®
An innovative way to hydropower generation

- An array („Matrix“) of small turbines instead of conventional sized turbines
- Best suited for low head sites with existing dam and weir structures
- Most economical in larger numbers -> not a typical „small hydro“ application
HYDROMATRIX®
A modular Concept in the “HYDRO-WORLD”
HYDROMATRIX®
Application criteria

- Available plant discharge minimum ~ 60 m³/s
- Available gross head from 2 m up to 20 m
- Minimum tailrace depth of 1.5 m -
- Minimum submergence of 0.3 - 4.0 m depending on gross head
- Unit output from 100 kW up to ~ 1500 kW
- Grid connection in close vicinity
- Structure available & suitable for HYDROMATRIX®
HYDROMATRIX®

Advantages

- **Use of existing weir structures**
  - No major civil construction → less cost
  - Little excavation & no coffer dams → less geological risk
  - No additional land usage -> environmentally friendly
  - Existing river flow pattern can be maintained

- **HYDROMATRIX® Modules removable at flood conditions**

- **Standardized modular concept**
  - Compressed project schedule
  - High availability & easy maintenance
HYDROMATRIX®

Application Range

- Grid connection in close vicinity
- Structure available & suitable for HYDROMATRIX®

Submergence
- \( H_{gr} < 12 \) m: Subm. = 0.3 – 2 m
- \( H_{gr} > 12 \) m: Subm. = 2.0 – 4 m

Unit Output
- 100 kW up to 1500 kW

Other Details
- Plant Flow ~ 100 m³/s
- Unit Flow > 5–12 m³/s
- Head 2.0 m - 20.0 m
- Tailrace Depth > 1.5 m
- Submergence 0.3 m - 4.0 m
HYDROMATRIX® Projects

Locations

- Lower St. Anthony Falls
- Colebrook
- Chievo
- Ashta I&II
- Nussdorf
- Agonitz
- Freudenau
- Jebel Aulia

- 19 years of product experience
- 7 reference plants totaling 200+ units and 100+ MW of capacity
HYDROMATRIX®
Operating Range of a single turbine-generator unit

Output Values includes already all electrical and hydraulic losses

The Unit outputs indicated on the charts consider the typical hydraulic and electric plant losses (Trashrack, friction, cabling, generator, transformer, etc.). The charts are suppose to give an orientation about the actual plant output which can be expected at the point of interconnection.

For performance optimization a detailed hydraulic layout is usually performed. Please contact ANDRITZ Hydro for questions and further details.
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HYDROMATRIX®

Energy Production

Typical Compact Hydro - solution

HYDROMATRIX®
9 units

HYDROMATRIX®
3 units
HYDROMATRIX®
Design Features

- Unregulated propeller turbine (aluminum bronze or stainless steel runner)
- Directly driven synchronous (Permanent Magnet Technology) or asynchronous generator
- Welded hydraulic steel structure
- Mechanical face seal
- Roller type bearings, oil sump lubrication
- Light weight (9 – 13 t) -> truckable
- Minimum maintenance
  -> annual oil change
- Flexible concept - Modular switchgear
**Turbine-Generator Unit Designs**

**HYDROMATRIX® versus StrafloMatrix™**

<table>
<thead>
<tr>
<th>HYDROMATRIX®</th>
<th>StrafloMatrix™</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Simple bulb design</td>
<td>▪ Generator outside of flow (straight flow)</td>
</tr>
<tr>
<td>▪ Synchronous / asynchronous operation</td>
<td>▪ Synchronous operation only</td>
</tr>
<tr>
<td>▪ Permanent magnet or squirrel-cage rotor</td>
<td>▪ Combined runner / permanent magnet rotor</td>
</tr>
<tr>
<td>▪ Higher output range than StrafloMatrix™</td>
<td>▪ 50% shorter and 30% lighter than HM</td>
</tr>
<tr>
<td>▪ PF compensation for asynchronous</td>
<td>▪ No PF compensation required</td>
</tr>
</tbody>
</table>

[Diagram of HYDROMATRIX® and StrafloMatrix™]
Turbine-Generator Unit Designs

HYDROMATRIX® versus StrafloMatrix™

G* ~ 15 t

Turbine

H* ~3,2 m
W* ~2,3 m

L* = 3,2 – 3,6 m

Generator

G* ~ 9 - 12 t

Turbine

H, W* ~ 2,2 - 2,5 m

L* = 1,75 m

Generator

*) Approximate weights and dimensions depend on individual plant configuration
HYDROMATRIX®
Type design range of a single turbine-generator unit

Border between: Low voltage \ Medium voltage Generator

TG - Unit Output

Turbine Discharge [m³/s]

Normal Operating Range

Exceptional Operating Range

ASG 0.69 kV
PMSG 3.3 kV
PMSG 4.16 kV

Hydro
HYDROMATRIX®
Synchronization and Operation of a Turbine-Generator Unit

- **Initial state**
  - Closed drafttube gate
  - TG-unit ready for start-up

- **Starting sequence**
  - Partial opening of drafttube gate
  - TG-Unit reaches nominal speed
  - Synchronization and grid connection

- **Normal operation**
  - Drafttube gate is fully opened
  - Power rise up to steady state

- **Shut down**
  - Closing of drafttube gate
  - Unit disconnected from grid at zero power
HYDROMATRIX®
Modular Design of Electrical Power Systems

GRID

PCC

PLANT

Switchgear

Module

Connection via:

OHL

MV Substation

HV Switchyard

Step-up / down Transformers

TG - Units

LV - Station Service

Connection via:

GRID

PCC

PLANT

Switchgear

Module

Connection via:

OHL

MV Substation

HV Switchyard

Step-up / down Transformers

TG - Units

LV - Station Service
HYDROMATRIX®
Typical Design of Protection and Automation

Unit / Plant Protection
Protection Relays

Remote Control (Optional)

Unit Control

Plant Control and HMI
Peripheral Bus Communication

250 SCADA System
Operator Station
Laser B/W Jet Printer

Relays
Peripheral Bus Communication
HYDROMATRIX®
Potential Applications

- Navigation Dams
- Irrigation Dams
- Intake Towers
- Canals and Abandoned Shiplocks
Application: Irrigation Dams
HYDROMATRIX® Experience
Irrigation Dams – JEBEL AULIA /Sudan

Client: National Electricity Corp.

D = 1,120 mm
n = 375 rpm
H = 5.5 m
\( P_{tu} = 380 \text{ kW} \)

80 Hydromatrix® units in 40 modules

\( P_{total} = 30.4 \text{ MW} \)

Existing barrage on the White Nile

Contract award: 2000

Commissioning: 2004
HYDROMATRIX® Experience

Irrigation Dams – JEBEL AULIA /Sudan

Jebel Aulia HYDROMATRIX® power plant, upstream view
HYDROMATRIX® Experience

Irrigation Dams – JEBEL AULIA /Sudan

HYDROMATRIX® Turbine-Generator Unit in lifted position
Switchgear containers & step-up transformer-downstream side of dam
HYDROMATRIX® Experience
Irrigation Dams – JEBEL AULIA /Sudan
StrafloMatrix™ Experience
AGONITZ / Austria

Client: Energie AG

D = 1,120 mm
n = 428.6 rpm
H = 8.5 m

$P_{tu} = 700$ kW

1 unit

Contract award: 2002
Commissioning: 2003
StrafloMatrix™ Experience
AGONITZ / Austria

Installation of the first permanent StrafloMatrix™ unit in March 2004
HYDROMATRIX® Experience
NUSSDORF/ Austria

Client: AHP / EVN / Wienstrom

After Commissioning in June 2005
HYDROMATRIX® Experience
NUSSDORF/ Austria

Client: AHP / EVN / Wienstrom

D = 1,320 mm

n = 336.7 rpm

H = 5.86 m

$P_{tu} = 545\ kW$

12 single units

$P_{total} = 4.5\ MW$

Contract award: 2004

Commissioning: 2005
HYDROMATRIX® Experience
NUSSDORF/ Austria

Plant Concept

- Overflown weir
- Intake trash rack with cleaning machine
- Intake- and draft tube gates
- Drainable turbine chamber with draft tube
- US-gallery for cables, HPU and unit maintenance
Application: Intake Towers
HYDROMATRIX® Experience
Intake Tower – COLEBROOK / USA

Client: Metro Hartford

D = 660 mm

n = 900 rpm

H = 8 - 35 m

\( P_{tu} = 500 \text{ kW} \)

6 units in 2 modules*)

\( P_{total} = 3 \text{ MW} \)

Contract award: 1987

Commissioning: 1988

*) Design by Obermeyer Hydro Inc.
Application: Shiplocks
HYDROMATRIX® Experience
Sluice in Shiplocks – FREUDENAU / Austria

Client: Donaukraft

D = 910 mm

n = 500 rpm

H = 10.3 - 1.0 m

P_{tu} = 200 kW

25 units in one module

P_{total} = 5 MW

Contract award: 1997

Commissioning: 2000
CHIEVO DAM - Italy

Project Location
CHIEVO DAM - Italy

Design Challenges

- Use minimum river discharge for hydropower generation at existing lock & dam
- Maintain flood discharge capability through lock
- Use existing lock structure without major modifications
- Preserve architectural appearance of historic environment
- Establish possibilities for fish migration
Module steel structure with integrated StrafloMatrix™ TG-units
**StrafloMatrix™ Experience**

**CHIEVO DAM / Italy**

Client: Consorzio Canale Ind. le G.Camuzzoni

Consultant: Studio Frosio

\[ D = 1,320 \text{ mm} \]

\[ n = 250 \text{ rpm} \]

\[ H = 3.8 \text{ m} \]

\[ P_{tu} = 270 \text{ kW} \]

5 units in 1 module

\[ P_{\text{total}} = 1.35 \text{ MW} \]

Annual Energy: 12 GWh

Project Start: 2007

Commissioning: 2009
StrafloMatrix™ Experience
CHIEVO DAM / Italy

StrafloMatrix™ hydro power plant, Downstream view

The Winner of Austrian State Award for Environmental and Energy Technology 2010
LOWER ST. ANTHONY FALLS - USA
StrafloMatrix™ Power Plant

LSAF prior to installation of StrafloMatrix™ power plant

LSAF after installation of StrafloMatrix™ power plant
LOWER ST. ANTHONY FALLS - USA

Design Challenges

- Use existing lock structure without major modifications (no excavation)
- Maintain flood discharge capability through lock
  - Model test at techn. university Vienna
- Fulfill grid interconnection requirements
- No adverse effects on barge and recreational boat traffic
- Preserve architectural appearance of existing lock and dam
LOWER ST. ANTHONY FALLS - USA
StrafloMatrix™ Plant in Auxiliary Ship lock

Technical Data:
16 TG-units (2 rows of 8)
D = 1,320 mm
n=327.3 rpm
H_{GR\ max} = 7.6 m
P_{Gen} = 625 kW
Max. Plant Capacity: 10 MW
Annual Energy: 62 GWh
Project Start: 2007
Commissioning and taking over: 2011
Output 8 % higher than guaranteed
LOWER ST. ANTHONY FALLS - USA
Site Construction and Equipment Installation
LOWER ST. ANTHONY FALLS - USA

StrafloMatrix™ Plant Features

HPU and switchgear inside underground gallery

StrafloMatrix™ TG-units in lifted position

Gantry Crane

Cable Reel
ASHTA I & II - Albania
A showcase for efficient project development

**Client:** VERBUND / Energji Ashta

**Fast Track development**
- Less than 2 years from concept to contract
- Highly experienced project owner
- Good collaboration between all stakeholders in Albania and Austria

**Main selection criteria for technology**
- Cost per kwh
- Shallow setting to minimize excavation and avoid geological issues
- No changes in flood planes

**Investigated Technologies**
- Conventional bulb versus HYDROMATRIX®
- HYDROMATRIX® was chosen -> lowest overall construction cost + all boundary conditions fulfilled
HYDROMATRIX® Experience
ASHTA I & II / Albania

Plant Layout:

- 2 HYDROMATRIX® Plants, 45 TG-Units each
- 6 km newly constructed discharge canal between ASHTA I & II
- Turn-key supply of E & M Equipment
- $P_{\text{rated, total}} = 53$ MW
- Annual Energy: 242 GWh
- Project Start: Dec. 2008
- Commissioning: 2012

Source: © Energij Ashta - A project company of VERBUND and EVN, used by permission
ASHTA I & II - Albania

General Layout

TECHNICAL DATA: ASHTA I
OUTPUT: 45 x 534 kW = 24.03 MW / 24.64 MVA
HEAD: 4.98 m

TECHNICAL DATA: ASHTA II
OUTPUT: 45 x 1,003 kW = 45.14 MW / 46.29 MVA
HEAD: 7.53 m
HYDROMATRIX® Experience

ASHTA I & II / Albania

ASHTA I draft tubes and powerhouse during construction

ASHTA I power house and crane during construction

ASHTA I turbine intake during construction
ASHTA I
Site Construction – Status January 2012
ASHTA II
Site Construction – Status January 2012

HYDROMATRIX® TG-units in lifted position, upstream view

ASHTA II Power House, downstream view
HYDROMATRIX® Experience

ASHTA I & II / Albania

Ashta I intake area
HYDROMATRIX® TG-Unit
Application: Navigation Dams
HYDROMATRIX® Concept

Navigation Dams – Ohio River
HYDROMATRIX® Concept study
Navigation Dams – Ohio River

Typical purpose of navigation dams:
- Navigation and flood control

HYDROMATRIX® concept:
- Installation of movable HYDROMATRIX® modules in existing water passage of spillways
- Flexible module design offers possibility for various plant configurations

Lock & Dam on the Ohio River
Example for design alternative: Several Power Modules installed in stoplog slots of the radial gate bays

HYDROMATRIX®: 2 x 17 units per Module

Runner Diameter: 1.25 m
Rated Net Head: 6.5 m
Rated unit Discharge: 10.6 m³/s
Rated Module Discharge: 360.4 m³/s
Rated output / TG unit: 500 kW
Total Rated Plant Output: 85 MW
HYDROMATRIX®
Contact Worldwide

http://www.andritz.com/hy-hydromatrix

For more information about HYDROMATRIX® please contact:

Günter Hetzmannseder
Phone: +43 (732) 6986 6429
E-mail: guenter.hetzmannseder@andritz.com

ANDRITZ HYDRO GmbH
A - 4031 Linz, Austria
Lunzerstrasse 78
Web: http://www.andritz.com