Hydropower

The multiple roles in water and energy

**Electricity**
For transportation, heat, power and light

**Water storage**
For flood mitigation, irrigation, water supply and navigation

**Energy Storage**
For peak load generation, energy balancing and grid stability
Hydropower
Global market overview

Technically feasible hydropower potential: ~ 16,000 TWh/year
Hydropower generation: ~ 3,930 TWh/year

Hydropower

Electrical energy generation scenario 2050
ANDRITZ HYDRO

Highlights

We are a global supplier of electro-mechanical systems and services ("from water-to-wire") for hydropower plants and a leader in the world market for hydraulic power generation.

More than 175 years of turbine experience (1839)

Over 31,600 turbines (more than 434,600 MW) installed

Complete range up to more than 800 MW

Over 120 years electrical equipment experience (1892)

Leading in service and rehabilitation

More than 120 Compact Hydro units per year
ANDRITZ HYDRO

History

The pioneers created the foundation.
The ANDRITZ GROUP

Overview

ANDRITZ is a globally leading supplier of plants, equipment, and services for hydropower stations, the pulp and paper industry, the metal-working and steel industries, and solid/liquid separation in the municipal and industrial sectors.

Headquarters: Graz, Austria

Global presence: over 250 production sites and service/sales companies worldwide

**KEY FINANCIAL FIGURES 2015**

<table>
<thead>
<tr>
<th></th>
<th>Unit*</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order intake</td>
<td>MEUR</td>
<td>6,017.7</td>
</tr>
<tr>
<td>Order backlog (as of end of period)</td>
<td>MEUR</td>
<td>7,324.2</td>
</tr>
<tr>
<td>Sales</td>
<td>MEUR</td>
<td>6,377.2</td>
</tr>
<tr>
<td>EBITA</td>
<td>MEUR</td>
<td>429.0</td>
</tr>
<tr>
<td>Net income (including non-controlling interests)</td>
<td>MEUR</td>
<td>270.4</td>
</tr>
<tr>
<td>Employees (as of end of period; without apprentices)</td>
<td>-</td>
<td>24,508</td>
</tr>
</tbody>
</table>

* MEUR = million euro
Company profile
Worldwide leading position in four business areas

<table>
<thead>
<tr>
<th>Business Area</th>
<th>Order Intake 2015</th>
<th>Sales 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>1,719 MEUR</td>
<td>1,835 MEUR</td>
</tr>
<tr>
<td>Pulp &amp; Paper</td>
<td>2,264 MEUR</td>
<td>2,196 MEUR</td>
</tr>
<tr>
<td>Metals</td>
<td>1,439 MEUR</td>
<td>1,718 MEUR</td>
</tr>
<tr>
<td>Separation</td>
<td>597 MEUR</td>
<td>628 MEUR</td>
</tr>
</tbody>
</table>

Note: figures above relate to the FY 2015
* Average share of ANDRITZ GROUP’s total order intake

Product offerings:
- Hydro: electromechanical equipment for hydro-power plants (turbines, generators); pumps; turbo generators
- Pulp & Paper: equipment for production of all types of pulp, paper, tissue, and board; energy boilers
- Metals: presses for metalforming (Schuler); systems for production of stainless steel, carbon steel, and non-ferrous metal strip; industrial furnace plants
- Separation: equipment for solid/liquid separation for municipalities and various industries; equipment for production of animal feed and biomass pellets

© May 1, 2016
www.andritz.com
ANDRITZ HYDRO
Facts and figures

<table>
<thead>
<tr>
<th>Central Function</th>
<th>Large Hydro</th>
<th>Compact Hydro</th>
<th>Service &amp; Rehab</th>
<th>Pumps</th>
<th>Turbo Generator</th>
</tr>
</thead>
</table>

ANDRITZ HYDRO FIGURES 2015

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order intake</td>
<td>MEUR</td>
<td>1,718.7</td>
</tr>
<tr>
<td>Order backlog</td>
<td>MEUR</td>
<td>3,640.9</td>
</tr>
<tr>
<td>Sales</td>
<td>MEUR</td>
<td>1,834.8</td>
</tr>
<tr>
<td>EBITA</td>
<td>MEUR</td>
<td>145.3</td>
</tr>
<tr>
<td>Employees (without apprentices)</td>
<td></td>
<td>8,230</td>
</tr>
</tbody>
</table>

Graph showing order intake, sales, and order backlog from 2013 to 2015.
Global test facilities
- 14 hydraulic test rigs
- 5 generator laboratories
- Pump laboratory

Advanced numerical calculation methods

Highlights
- Turbine test facilities including all types:
  - High heads up to 2,000m
  - Low head Bulb turbines
  - Pump turbines
- Generator test fields for:
  - Large rotating electrical machines up to 850 MVA
  - Bearings
  - Electrical insulation
ANDRITZ HYDRO
Global manufacturing

- **Main Products**
  - Hydro mechanical components
  - Turbine components
  - Hydro and turbo generators
  - Electrical components

- **Locations**
  - Europe
  - Asia
  - North America, South America

- **Capacity**
  - In-house manufacturing capacity
    - ~ 2,500,000 hours/year
  - On-site assembly capacity
    - ~ 800,000 hours/year
  - Total manufacturing area
    - > 170,000 m²
ANDRITZ HYDRO
System and service scope of supply – “from water-to-wire”

1 Gates
2 Penstocks
3 Inlet valve
4 Turbine
5 Generator
6 Automation, Control & Protection
7 Medium voltage switchgear
8 Power transformer
9 High voltage switchgear
10 Transmission line
Scope:
- Turnkey electro-mechanical package for hydropower plants
- New hydropower plants
- Large rehabilitations and upgrades
- “from water-to-wire” (W2W)
- Project development

Highlights:
- Market leader Pelton turbines
  - 423 MW, 1,874 m – 2 world records
  - Bieudron / Switzerland
- Large Francis turbines
  - 770 MW – Guri II / Venezuela
- Market leader Bulb turbines
  - 76.55 MW – St. Antonio / Brazil
- Large hydro generators
  - 840 MVA – Three Gorges / China
Hydro-mechanical structures
Penstocks and Gates

- Scope:
  - Steel structures for hydropower plants, water supply and irrigation
  - Exposed and embedded penstocks
  - Pipe bridges and steel tunnel linings
  - Manifolds and bifurcations
  - Gates and hydraulic steel constructions

- Highlights:
  - Large gates:
    - Pimental / Brazil
  - Large penstock
    - Ø 13.26 m – Tarbela Dam 3 / Pakistan
  - Large manifold
    - 16 m high – Tarbela Dam 3 / Pakistan
  - High head
    - 2,070 m – Cleuson-Dixence / Switzerland
Small and mini hydropower plants
Compact Hydro

- **Scope:**
  - Small hydropower plants (units up to 30 MW)
  - Mini hydropower plants (units from 20 kW up to 5,000 kW)
  - “from water-to-wire” (W2W)
  - Modular system design
  - Pre-assembly at workshop

- **Highlights:**
  - Small hydro supplied to Turkey
    - More than 1,000 MW
  - Large Compact Pelton turbine
    - 30.3 MW – Renace II / Guatemala
  - Drinking and waste water turbines
    - 200 kW – Val Mila / Switzerland
    - 6 MW – Las Vacas / Guatemala
  - Energy recovering turbine (mines)
    - 3x 1.54 MW – Saaiplaas / S-Africa

Each week two new Compact Hydro units start working!
Modernization
Service & Rehabilitation

- **Scope:**
  - Solutions, products and services over the entire life cycle of a hydropower plant
  - General overhaul / rehabilitation
  - Uprating / upgrading / modernization
  - Plant assessment
  - Technical studies
  - Residual life analysis
  - Risk assessment

- **Highlights:**
  - **Uprating**
    - + 40% - Ambuklao/Philippines
    - + 400 MW – Guri II / Venezuela
  - **Replanting and uprating**
    (replacement of 12 units by 5 units)
    - + 20% (5x 17.3 MW) – Lochaber / UK
  - **Rehabilitation of largest single phase hydro generator**
    - 94 MVA, 34 t pole weight
    Langenprozelten / Germany
Electrical power train
Electrical Power Systems

- **Scope:**
  - Solutions, products and services for complete range of electrical equipment for hydropower plants
  - Plant and power engineering including system and grid studies
  - Integration of all systems ("from water-to-wire")

- **Highlights:**
  - Electrical system for pumped storage
    - 4x 300 MW – Tong Bai / China
  - Complete electrical equipment for
    - 6x 130 MW – Karahnjukar / Iceland
  - Complete electrical equipment for
    - 2x 55 MW – Chacayes / Chile
  - Turnkey electrical equipment including 420 kV high-voltage substation
    - 4x 130 MW – Beles / Ethiopia
Secondary equipment
Automation

- **Scope:**
  - Complete automation solutions for
    - All sizes of power plants
    - Newly built power plants
    - Rehabilitation
    - Upgrading and modernization
    - Integration of existing systems

- **Highlights:**
  - Large excitation (field current 3,200 A)
    - 10x 850 MVA – Guri II / Venezuela
  - HIPASE – Integrated platform for protection, excitation, turbine governor and synchronization
  - Large dispatch center applications
    - Regional dispatch center
      110 HPP's of EON – Landshut / Germany
    - Dispatch center for Norway
      Statkraft / Norway
Pumps, motors and hydrodynamic screws

Pumps

- **Scope:**
  - Standard and customer-specific pumps:
    - Water, waste water or sea water
    - Cooling water pumps *(power plants)*
    - Offshore
    - Mining
    - Industry
      (pulp, paper, sugar, chemical or food)
    - Mini hydro power generation

- **Highlights:**
  - Very large flowrates
    (e.g. water infrastructure in India and China)
  - Highly abrasive applications
  - Modular multistage concept with highest efficiencies
  - Engineered multistage pumps up to 35 MW
  - Pump storage operations
Gas and steam turbine generators
Turbo Generator

- **Scope:**
  - Turbo generators for gas and steam turbines from 8 MVA up to 350 MVA
  - 50 and 60 Hz
  - **Type**
    - Air-cooled
      - TEWAC (air-water-cooled)
      - Open ventilated
      - CACA (air-air-cooled)
    - Hydrogen-cooled

- **Highlights:**
  - > 1,265 turbo generator units
  - > 137,000 MVA total output ever built
  - Turbo generators for
    - Heavy duty gas turbines (HDGT)
    - Aeroderivative gas turbines
Hydropower market outlook
Low head applications for existing structures

- **Trends:**
  - Innovative solution for:
    - existing dams, gates, weirs, etc.
    - greenfield projects
  - Usage of ecological flow for additional power generation

- **Highlights:**
  - Largest HYDROMATRIX® plant
    - 45x 534 KW – Ashta I / Albania
    - 45x 1,003 kW – Ashta II / Albania
  - Usage of abandoned shiplocks
    - 5x 270 kW StrafloMatrix™ Chievo / Italy
Hydropower market outlook
Develop ocean energy

- **Trends:**
  - Technology for power generation from tidal lift and tidal currents
    - Tidal lagoon (energy island)
    - Tidal array
    - Tidal barrage

- **Highlights:**
  - World largest tidal power plant
    - 10x 26 MW – Sihwa / South Korea
  - Rehab of first tidal power plant
    - 24x 10 MW – La Rance / France
  - First commercial tidal current turbine
    - 1x 1,000 kW (HS1000) – EMEC / UK
  - First commercial array
    - 3x 1,5 MW – MeyGen / Scotland
  - New developments for tidal lagoons
Hydropower market outlook
Pumped storage power plants

▪ Trends:
  ▪ Solution as “battery of the grid”
  ▪ “from water-to-wire” (W2W)
    ▪ Fixed or variable-speed
  ▪ Electrical grid compatibility
    ▪ Grid code compliance

▪ Highlights:
  ▪ First variable-speed pumped storage plant in Europe
    ▪ 4x 325 MW – Goldisthal / Germany
      (2x variable-speed units á 340 MVA)
  ▪ High speed pumped storage (750 rpm)
    ▪ 2x 240 MVA – Reisseck II / Austria
  ▪ Quick change (+540 / -540 MW in 20 sec)
    ▪ 3x 200 MVA – Kops II / Austria
All operational Divisions and Subsidiaries are certified according to the Standards ISO 9001, ISO 14001 and OHSAS 18001.

Quality one can rely on!
ANDRITZ HYDRO

Your partner for renewable and clean energy