HYDROELECTRIC POWER GENERATION

Hydroelectric power is a reliable renewable energy source accounting for over 1,400 GW of installed capacity, or currently about 17% of the world's energy. Many countries continue to expand capacity with Brazil, Canada, and China accounting for the most hydroelectric projects currently under construction. Hydroelectric power uses the water stored in dams and flowing in rivers to create electricity in hydropower plants. With efficiencies reaching up to 95%, hydroelectric is a suitable method for generating electricity. Today, hydroelectric power plays a more important role even as the industry continues to increase capacity for other forms of renewable energy like wind and solar. Hydroelectric power's flexibility provides base load and peaking power, frequency recovery, and start-up capabilities encompassing both the normal operation and auxiliary services.

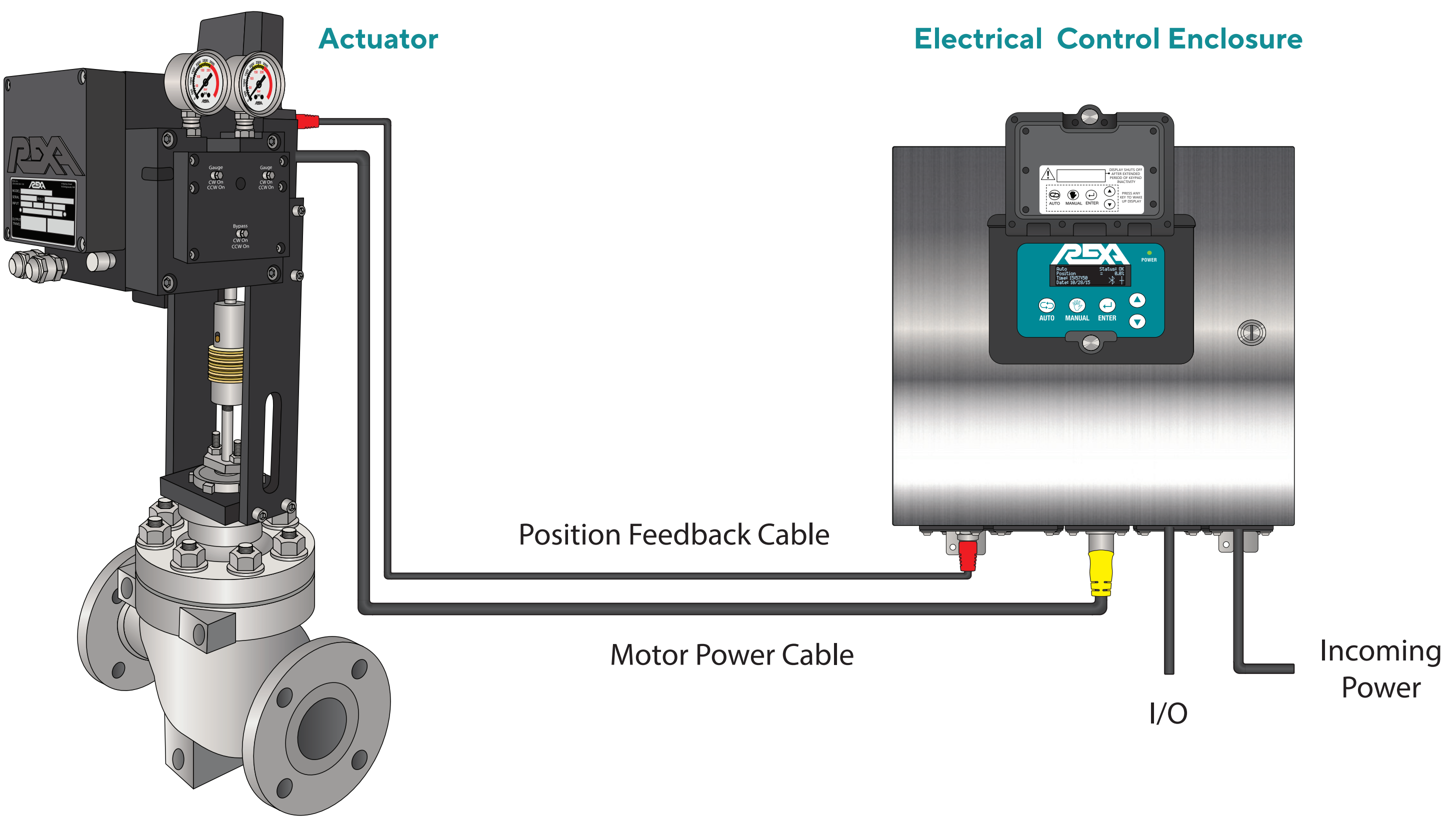
Hydroelectric utilizes hydrokinetic energy where the change in elevation of water generates a force to rotate a turbine(s) (also referred to as runners) that is then converted into electrical energy. The greater the elevation of water, the greater the pressure and force that can be generated. Along with generating electricity, hydroelectric development provides other services such as recreation, flood control, navigation, irrigation, and drought mitigation. These valuable services enhance communities, reduce environmental impact, and drive economic development worldwide.

Hydroelectric Power Generation

There are generally two types of conventional hydroelectric plants: Impounded and Run-of-the-River. Impounded plants block the body of water and regulate discharge with the weir, spillway, and turbine. In contrast, the Runof-the-River allows the body of water to flow through the powerhouse. Along with generating electricity, hydroelectric development provides other services such as recreation, flood control, navigation, irrigation, and drought mitigation. These valuable services enhance communities, reduce environmental impact, and drive economic development worldwide.

Why REXA?

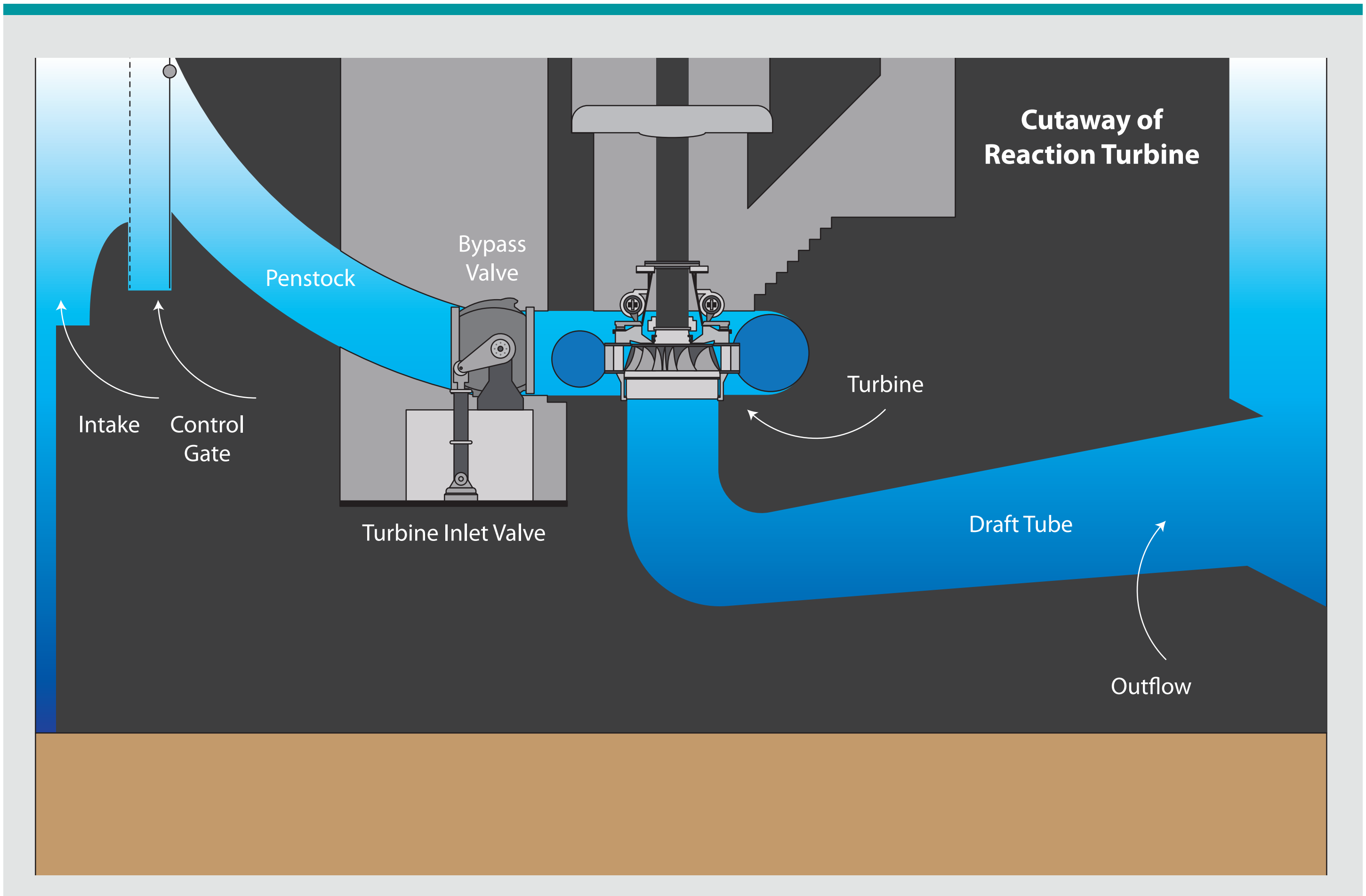
At REXA, we have more than 25 years of experience in the hydroelectric power market. We offer high quality, low/ no maintenance Electraulic™ Actuators that provide flexible operation for low to high duty cycle requirements with minimal environmental impact. This ensures reliable operation with reduced maintenance costs for hydroelectric power plants.



Reaction Turbines

Reaction Turbine designs cover a wide spectrum of turbine types to convert hydrokinetic energy into electrical energy. Types of reaction turbines include Francis, Propeller, Kaplan, Bulb, and Banki typically used for elevations between 5 – 200 meters. These turbines can be arranged in various positions including horizontal, vertical, or on an incline according to the design of the plant and turbine type. The variety of turbine types and arrangements are dependent on many variables, such as available head levels. Axial flow propeller turbines are typically used for lower head applications, while Francis turbines can be used on a wide range of elevations. Water (usually isolated from ambient pressure inside a penstock) moves through to the turbine, increasing in pressure as it reaches it, allowing the flow of water to rotate the turbine runner. The water travels either radially with the axis, or a combination of both through the turbine. Most reaction turbines utilize wicket gates to regulate the flow of water through the turbine runners. Wicket gate operation is critical for positioning as well as the ability for reliable and tight shutoff during an upset condition.

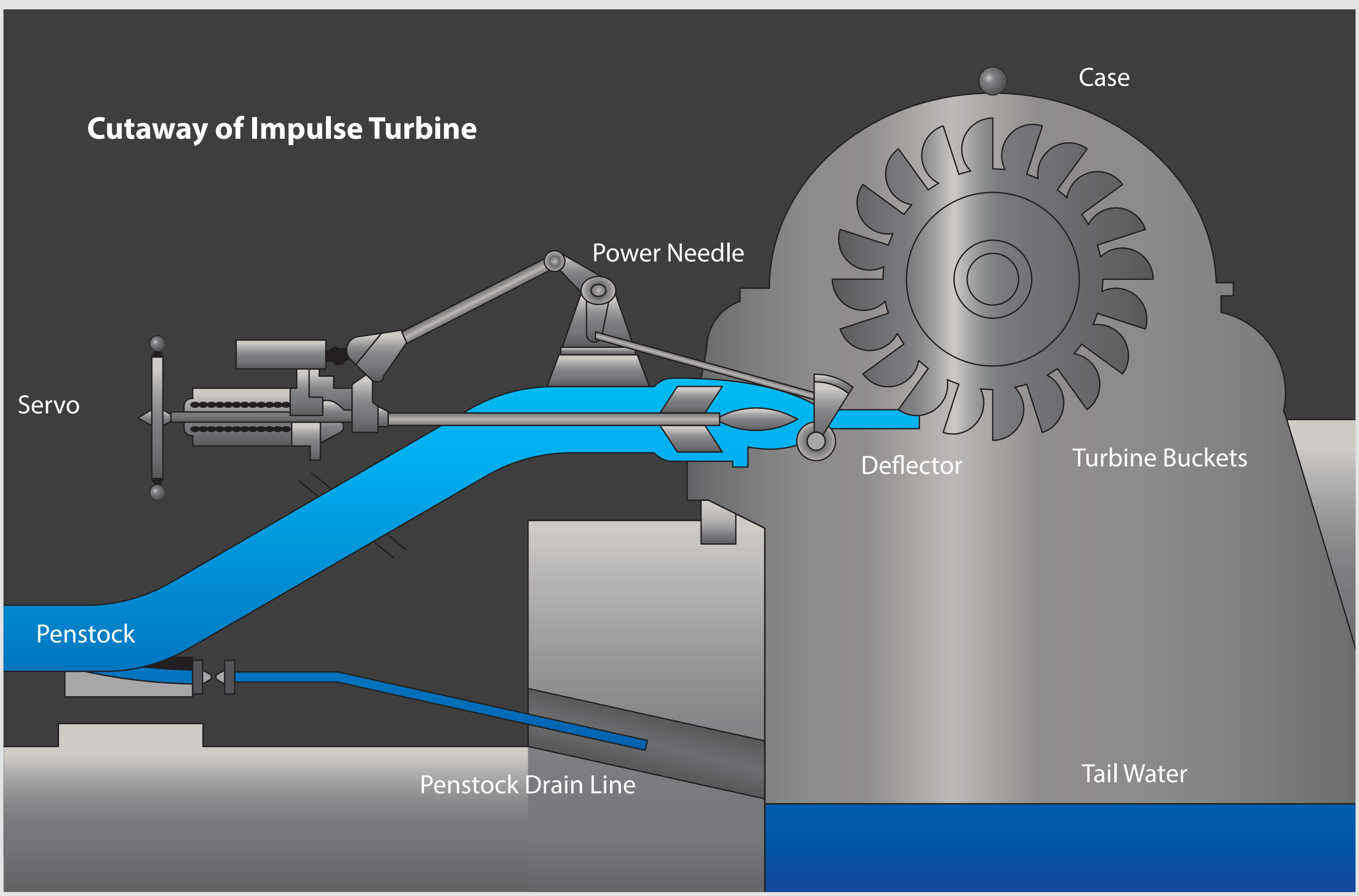
"We've had a lot of success with REXA Actuators in our other [coal] plants. We decided to apply them on some of our hydro turbines. They are very well suited for the application and operate well under different conditions. The units have been installed for several years and have not had any maintenance done to them…"



Impulse Turbines

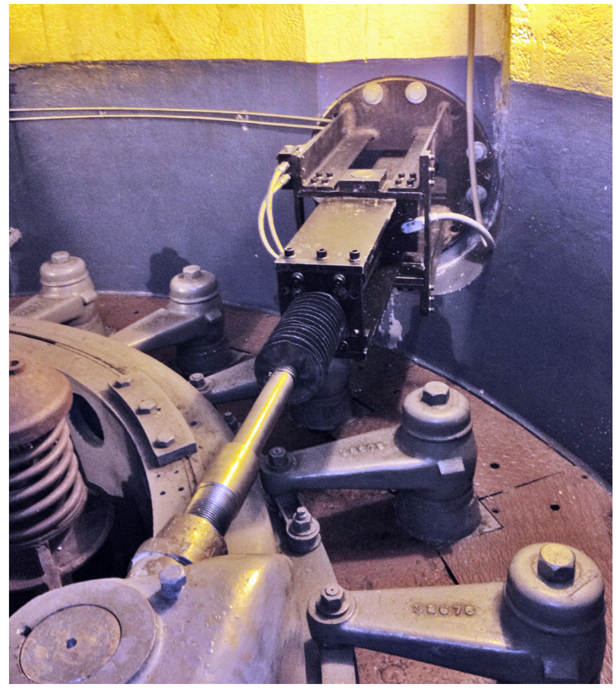
Impulse turbines are used when there is high head available with less available flow. The head range for impulse turbines is typically 80-2000 meters. Pelton and Turgo are the types of impulse turbines. Impulse turbines can also be arranged horizontally, inclined, or vertically according to the design of the plant and turbine type. As the water is being conveyed through the penstock, it increases in pressure. Once the water comes to the turbine, the water under pressure is converted into a high velocity jet stream as it is released from a needle valve called a power needle. The jet stream impinges on the turbine buckets rotating the unit to generate electricity. The power needle sometimes coupled with a deflector, controls the water jet. The jet stream is open to atmosphere and secured inside the deck's casing. Single or multi jet arrangements can be utilized for turbines. Controlling the speed of the power needle to go either in the closed or open direction is a critical function of the application to regulate the flow of the water jet as well as prevent water hammer in the penstock. Another critical function is having tight, precise positioning that can be under a centimeter between step changes.

"The main reason for choosing REXA Electraulic™ Actuation was having the ability to reduce the oil volumes by a significant amount while maintaining our current operations. REXA has helped us reduce the risk of spills and cut down on maintenance costs..."



Wicket Gates

Wicket gates are a series of adjustable vanes controlling the flow of water to a reaction turbine. Each vane (mechanically in parallel) is attached to an adjustable gate ring. Actuating the gate ring either clockwise or counterclockwise positions the wicket gates to regulate water flow. Hydraulic Power Units (HPUs) are the most common method to actuate wicket gates. Degradation of hydraulic fluid can cause problems for HPUs, which can lead to sluggish performance and ultimately disable the oil pressure system – causing an increase in downtime and maintenance costs. In addition, HPU systems pose a higher environmental risk as they contain hundreds (sometimes thousands) of gallons of oil. The consequences of potential discharge into waterways are severe. Upgrade to REXA to eliminate oil volumes by 95% for a more environmentally friendly solution!



Power Needle

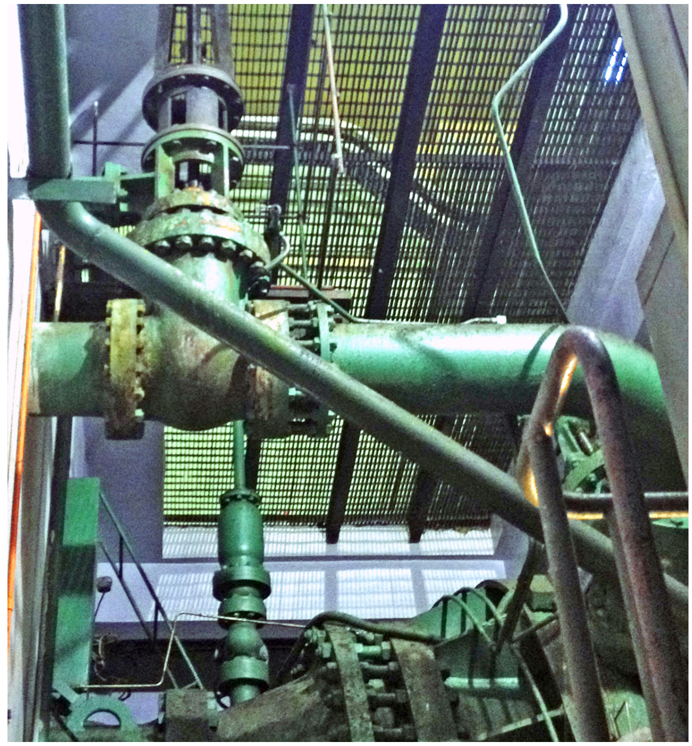
Accurate control of the power needle is critical in any hydroelectric power plant with an impulse turbine configuration. As part of the impulse turbine's nozzle, the power needle controls the water jet impinging on a series of buckets rotating the turbine runner. Power needles work in conjunction with governing control. If the generator/plant protection scheme detects low frequency, it activates the power needle to recover frequency by opening the needle during system separation and load acceptance (i.e. more power to the turbine).

REXA Electraulic™ Actuation has the required power and reliability for power needles to safely regulate water flow during both normal and islanded operation.

Turbine Inlet Valve

Hydroelectric power plants with a reaction turbine usually include a Turbine Inlet Valve (TIV) and a Turbine Inlet Valve Bypass on the downstream end of the penstock before the turbine. During startup before the TIV can be opened, the TIV Bypass opens to equalize pressure upstream and downstream of the TIV. Responsive and reliable opening/closing of the TIV Bypass is essential to equalize pressure upstream and downstream of the TIV before spinning the turbine in the startup sequence. If pressure isn't balanced, a turbine can experience turbulence, cavitation and mechanical shock/ fatigue that reduces the life of the equipment or disables it altogether.

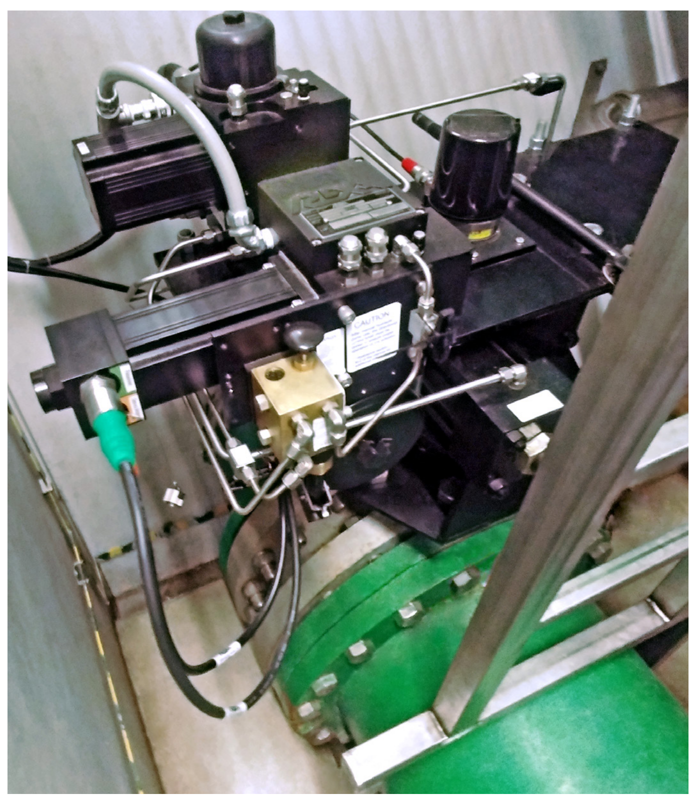
REXA actuators' accurate control and reliable positioning of the TIV Bypass ensures a safe startup sequence every time.



Turbine Bypass Valve

Turbine bypass valves are an essential part of reaction turbines. Bypass valves act as a backup to allow continuous operation in case equipment damage or failure occurs. Unstable performance of these valves creates both inefficient and potentially dangerous operating conditions. Bypass valves require reliable positioning, which pneumatics are not capable of. Air compressibility and static friction lead to overshooting and a constant hunting for target setpoint. Without reliable bypass valve operation thanks to pneumatic performance limits, plants are forced to reduce output in favor of safe and stable operation.

Upgrading to REXA Electraulic™ Actuation ensures reliable and repeatable bypass valve positioning, providing years of trouble-free operation!



Headquarters & Factory
REXA, Inc.
4 Manley St.
West Bridgewater, MA 02379
Tel: 508-584-1199

Sales, Service, & Training
REXA, Inc.
20338 Telge Road, Building E
Tomball, TX 77377
Tel: 281-944-4490

Sales & Service
REXA, Inc.
7110 Oak Ridge PKWY. Suite 170
Austell, GA 30168
Tel: 770-857-0003

MADE IN USA

www.rexa.com

IB-9_12.24