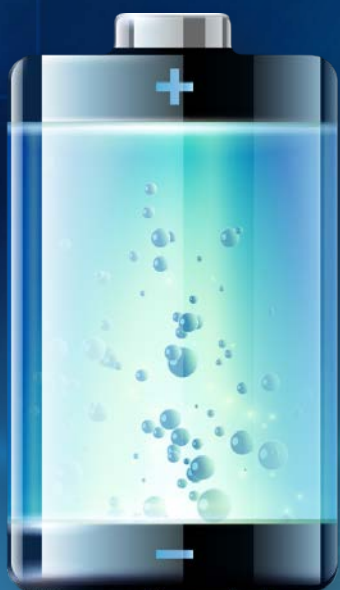




MODERN HYBRID SOLUTION FOR HYDROPOWER

HYBATEC



ANDRITZ

ENGINEERED SUCCESS

The global energy market is changing

We are living in a rapidly changing world. Even though these changes may take years or even decades to take effect, they are long-term and fundamental. At a time, when power generation based on fossil resources is being replaced by a carbon-free renewable electrical energy production, a compromise between the needs of the present and responsibility to future generations has to be found.

We are facing a dramatical change in the global energy market – from a fossil fuel or nuclear based generation to a carbon-free renewable generation. In addition to structural changes, there are many market challenges to address. Issues such as market liberalization, energy prices, base- and peak load capacity, the impact of weather, and smart metering technology must all be resolved.

Anticipated future requirements include calls for frequency regulation by run-of-river power plants, mini pumped storage for balancing small wind farms,

ocean energy applications combined with off-shore wind farms, and small hydro to balance the impact of clouds passing over a solar plant, as well as upgrading of all existing power plants to new standards and network codes, and linking them with the digital world.

How can we solve these challenges? The ideal approach is a combination of the best features of all involved systems – a hybrid solution. Today, examples of hybrid solutions are known from the automobile industry, computer technology, and also from nature.



Large-scale hybrid solutions and mega batteries

For the power industry, hybrid solutions are defined as a combination of one or more generation technologies involving at least one renewable energy source and an energy storage system. This ensures maximum supply reliability and security of energy supply.

To meet the new requirements and to realize new possibilities engineers and experts of different disciplines are joining forces creating new innovative solutions. Over the past years some large-scale hybrid projects were realized using different combinations of wind, solar, or hydropower. Some interesting examples are:

GONORA DEL VIENTO / SPAIN

Gorona del Viento is located on El Hierro, the second smallest Canary Island. To guarantee the energy supply for about 5,000 families, increase the renewable energy rate, compensate the short-term wind volatility, and reduce fossil fuel and CO₂ emissions, a 11.5 MW wind farm combined with a pumped storage plant are forming a large-scale hybrid solution. ANDRITZ provided the Pelton turbines for this project.

KIDSTON / AUSTRALIA

In Northern Queensland, an existing large solar farm (270 MW) and a pumped storage plant (250 MW), using an old gold mine, will be the first "base load renewable" bulk energy asset. The hybrid solution will compensate any volatility of the grid as well as up to eight hours of night time operations in the absence of sunlight. ANDRITZ was selected for the supply of the electro-mechanical equipment for the pumped storage plant.

HORNSDALE POWER RESERVE / AUSTRALIA

Industrial mega battery plants are growing around the globe. Triggered by a major electricity blackout in South Australia, by end of 2017 an industrial 100 MW / 129 MWh battery plant was built within just 100 days to compensate grid volatility and provide energy for 30,000 homes for approximately 1 hour.



HyBaTec – the hybrid solution dedicated to the hydropower industry

HyBaTec (Hybrid Battery Technology) is a hybrid energy solution combining a hydropower unit with a battery. Compared to a conventional hydro application and – depending on the size of the battery – the operation range can be extended up to +/- 25%.

In addition to the large-scale hybrid solution, ANDRITZ is implementing hybrid approaches for our core products and services. Especially for low-head hydropower plants a reconsideration of the traditional operation approach is necessary. New demands require fast response times, frequent load changes, frequency regulation, and extended operational ranges. ANDRITZ is now offering a new hybrid solution that integrates a battery storage system into a hydropower plant – HyBaTec.

The system can be applied to “greenfield” applications as well as retrofitted to existing facilities, covering battery capacities from 100 kWh up to 10 MWh. Our hybrid solution is able to increase or keep the operational flexibility of your hydropower plant also under changing legal water regulations in the future.

Along with the existing run-of-river operational mode, other operational modes and additional grid services are possible using the HyBaTec solution. Faster response times and very flexible operation due to the interaction of the generation unit and the battery will be possible without restrictions resulting from electrical, mechanical or hydraulic limitations.

The battery can be either installed in a container in order to be mobile or can be integrated in cubicles directly within the hydropower plant building. In any event the battery will be integrated into the electrical

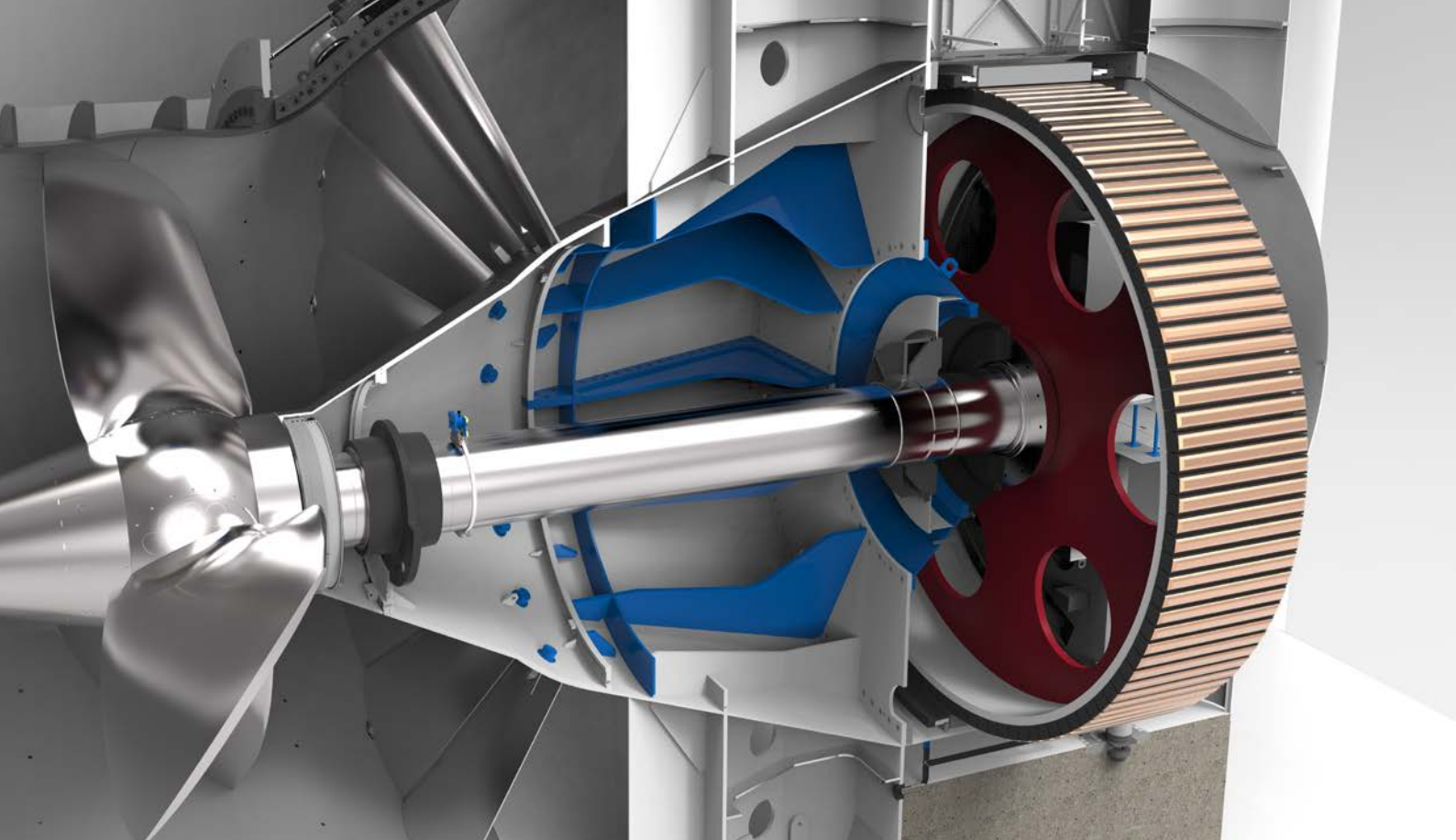
power plant as well as in the control system to optimize revenue from the system. The ANDRITZ Station Controller (ASC) includes the energy management system and manages both the turbine and the battery. An optimized HyBaTec solution is able to decrease the mechanical stress of the components and therefore extend the lifetime of the asset.

SUCCESSFUL PROJECT DEVELOPMENT

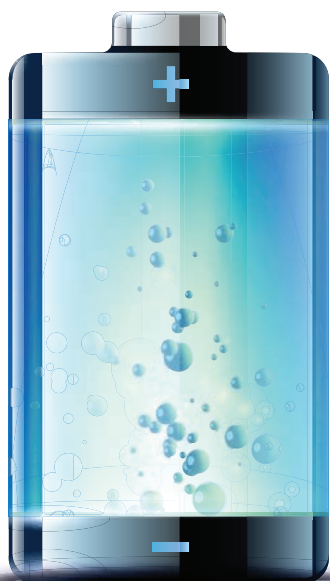
HyBaTec is more than a battery – it’s a solution based on long-term experience and expertise. To develop the best solution the impacts and cross-links from and between several topics have to be checked, evaluated, and solved. Typical topics are:

- **Turbine (mechanical capability, governor, grid code, ACC)**
- **Generator (electro-mechanical capability, excitation, grid code, PSS)**
- **Battery (supply time, capacity, charge/discharge rate)**
- **Grid requirements (grid code, volatile impact)**
- **Operation strategy (business case, lifetime, grid, storage)**
- **Energy stock market (tariff, base/peak load week, day-ahead, intraday spot market)**
- **Legal requirements (sunk/swall, feed-in contract, laws)**
- **Environment (fish-friendliness)**





**"HyBaTec is offering new possibilities
for the economic feasibility of your
hydropower asset."**



HIGHLIGHTS

- Extended energy range
- Fast implementation
- Increased lifetime of mechanical components
- Fast response times
- Flexible power (also in part load at start-up)
- High operational flexibility

HyBaTec application cases for your business

HyBaTec – the integrated hybrid solution is able to improve and expand your business cases with a range of benefits.

OPERATIONAL MODE “LIFETIME”

Today, most of the double regulated low-head turbines are operating in frequency control mode, driven by the grid and the commercial aspects of the energy market. In the past, these units were operated in level control with only a few mechanical movements per day. The frequency control has changed this behaviour dramatically. Nowadays, servomotors, bearings and wicket gates as well as blades have to cope with a lot of changing load cycles and therefore are suffering increased mechanical stress.

The main objective of HyBaTec’s operational mode “Lifetime” is to stabilize and balance the fast and short-term grid frequency demands out of the battery. The movements of the mechanical parts will be reduced and extend the lifetime of the hydropower unit drastically. At the same time, maintenance costs are reduced significantly.

The battery will be dimensioned to about 2.5% of the installed unit capacity and will operate between 50-70% charge to reach maximum lifetime.

OPERATIONAL MODE “GRID”

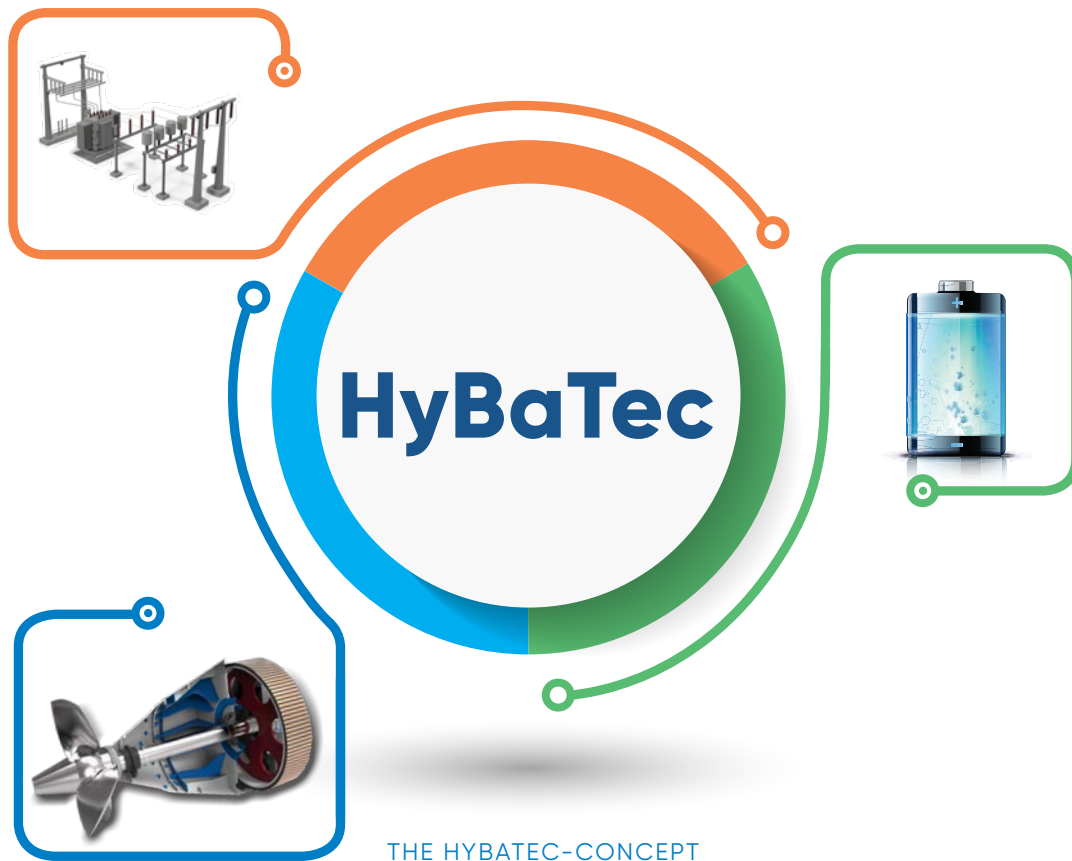
Low-head hydropower plants are limited in the participation of the short-term energy market (day-ahead, intraday) due to the lack of storage capacity and legal water management restrictions, the Water Framework Directive for level changes (swall/sunk) for instance.

The main objective of HyBaTec’s operational mode “Grid” is to provide opportunities to participate in the primary and secondary control market. One precondition is the availability of a defined amount of energy over a limited period of time (e.g. in Europe, 1 MWh for 30 min within seconds).

The battery is able to deliver very fast additional power to the grid. The overall energy response is realized by rapid response out of the battery and slow or damped reaction of the turbine. Charging of the battery is realized in between discharge periods out of the turbine. Pressure pulsations and fluctuations in part load operation can be reduced or avoided, turbine lifetime extended, and hence, the profitability of the asset improved.

The battery will be dimensioned to about 5-20% of the installed unit capacity and operates in partial charge-discharge cycles, depending on the market and the time to fully charge/discharge the battery, according to requirement and restrictions.





THE HYBATEC-CONCEPT

OPERATIONAL MODE "STORAGE"

Hydropower units are typically dimensioned based on the expected maximum load. In most cases this load is not requested over the whole operational day. The load shifting of the energy demand over a day offers new opportunities for the dimensioning of the units of greenfield projects.

The main goal of HyBaTec's operational mode "Storage" is to store a limited and defined amount of energy over the day presenting the above mentioned advantage for the optimization of the unit already during the design phase.

The battery will be dimensioned to about 15-25% of the installed unit capacity and is operating in full charge-discharge cycles. Because of the energy shifting aspect, these batteries have a storage capacity of two to four hours.

In addition to the dedicated applications, the battery storage system of HyBaTec provides additional benefits, such as covering the self-consumption demand during periods of low tariff (units stopped) or providing black start capacity for island operation.

The HyBaTec battery storage system is typically supplied in standard containers, able to provide mobile energy. On demand the HyBaTec containers can be transported with trucks to the respective sites to provide electrical energy for rural applications or for regional ad-hoc energy demands.



ANDRITZ HYDRO GmbH
contact-hydro@andritz.com

[ANDRITZ.COM/HYDRO](https://www.andritz.com/hydro)

ANDRITZ

All data, information, statements, photographs and graphic illustrations in this brochure are without any obligation and raise no liabilities to or form part of any sales contracts of ANDRITZ GROUP or any affiliates for equipment and/or systems referred to herein. All rights reserved. No part of this copyrighted work may be reproduced, modified or distributed in any form or by any means, or stored in any database or retrieval system without the prior written permission of ANDRITZ HYDRO GmbH or its affiliates. Any such unauthorized use for any purpose is a violation of the relevant copyright laws. © 2019 ANDRITZ HYDRO GmbH, Eibesbrunnnergasse 20, 1120 Vienna, Austria.

