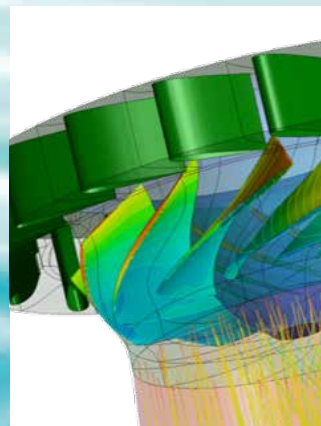


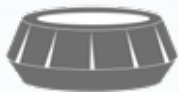
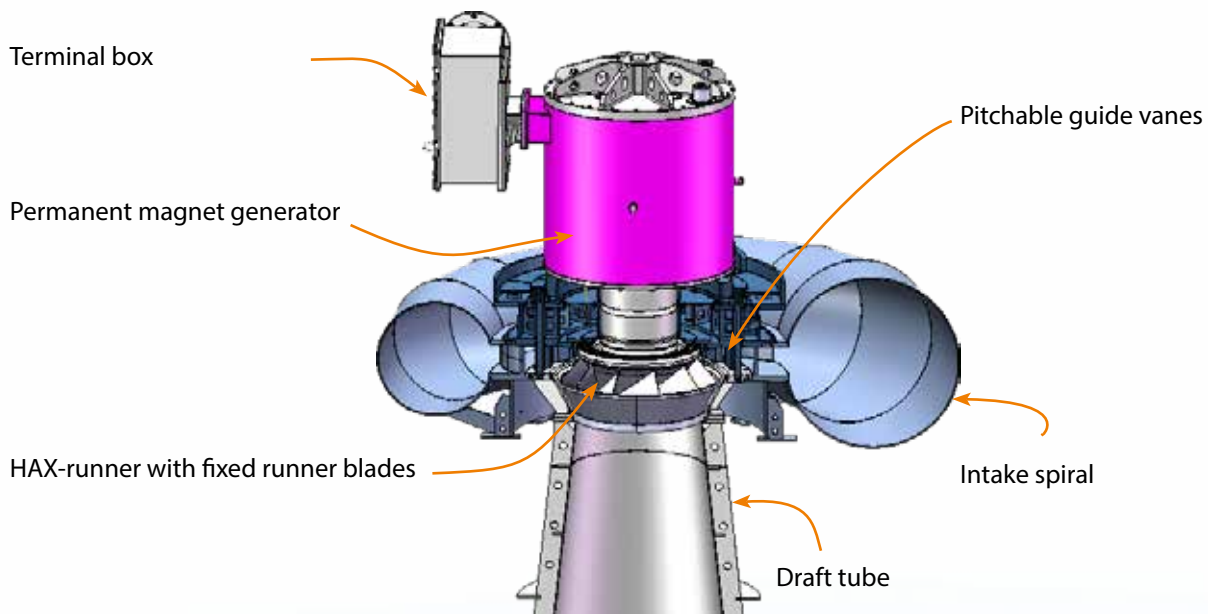


# DIVE-HAX-TURBINE

A double regulated half-axial (HAX) turbine for medium head applications



# DIVE-HAX TECHNOLOGY



## Half-Axial (HAX) runner with fixed runner blades – double regulation by speed variation and pitchable guide vanes

The double regulated DIVE-HAX-Turbine can operate from 5% to 100% of its installed discharge capacity and at a wide range of head variations. Thanks to the double regulation it can be operated with high efficiencies at different operating points. Therefore the DIVE-HAX is replacing a two-unit (Francis) with the single unit for medium head applications.



## Particle size

The geometry, fluid mechanics and the materials of the DIVE-HAX have a significantly higher resistance against abrasion due to sediments. Therefore the DIVE-HAX-Turbine can handle bigger particles compared to a Francis-Turbine. Therefore the de-sanding requirements are less critical and the sand trap can be designed much smaller. Therefore the required space, cost and head losses of the sand trap are significantly lower.



## Patented DIVE-Bearing and DIVE-Sealing

Maintenance-free sealing concept and only one longlasting bearing unit for turbine and generator: The whole turbine-generator unit is permanently submersible (flood-proof).



## Permanent magnet generator – no mechanical transmission

The permanent magnet generator is directly connected with the turbine.

## DIVE-HAX APPLICATION

### Head

20 m - 120 m

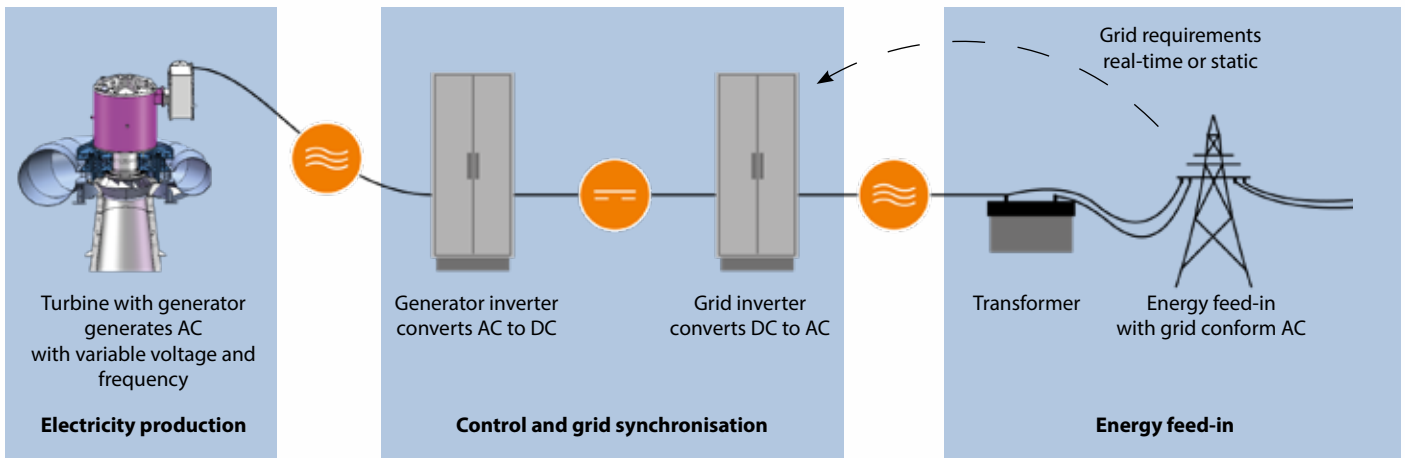
### Flow per unit

1 m<sup>3</sup>/s - 20 m<sup>3</sup>/s

### Capacity per unit

300 kW - 4 MW

# DIVE-HAX SPEED VARIATION



## Safe conditions at runaway speed

The bearing unit and sealing system of the DIVE-Turbine is able to handle runaway speed without the risk of damaging any parts of the turbine, even without auxiliary power supply. Therefore the operational risks are minimal, especially when the power plant is connected to an electrical grid with frequent grid failures. Additionally it allows to close the guide vanes slowly to avoid a water hammer in the system.



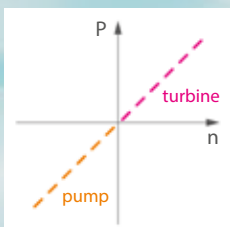
## Capable of direct grid connection and hybrid solution

In case of constant hydraulic parameters it is possible to connect the DIVE-HAX-generator directly to the grid to reach highest efficiencies without inverter losses. For power plants with high annual full load operation and still significant part load operation a hybrid solution is possible: the inverters are bypassed at full load. In part load they are re-connected.



## Minimum time for grid synchronisation and real time adjustments

The inverter operation allows the grid connection already at 5% load. The system is black start capable.  $\cos \varphi$  and output voltage can be adapted according to real-time or static grid requirements.



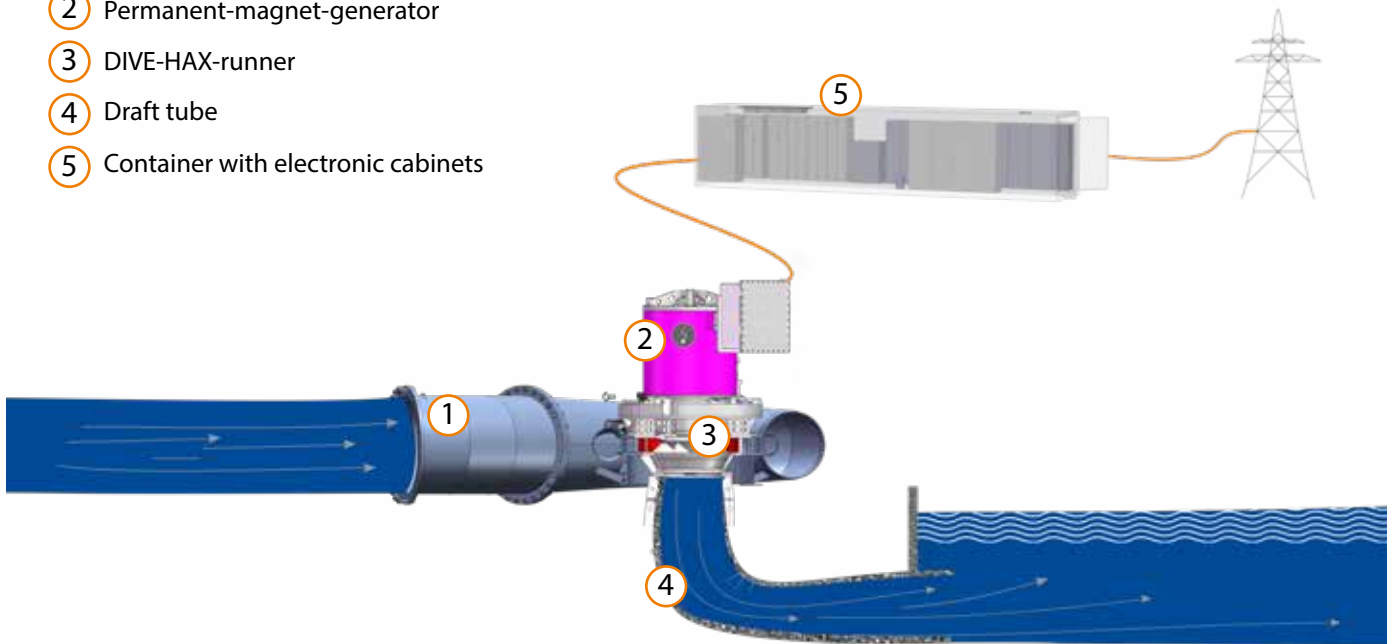
## Suitable for pump storage applications:

- + one runner for pump and turbine
- + inverter operation allows for change of runner direction
- + operation at different head levels
- + black start capable



# DIVE-HAX POWER PLANT LAYOUT

- ① Intake spiral
- ② Permanent-magnet-generator
- ③ DIVE-HAX-runner
- ④ Draft tube
- ⑤ Container with electronic cabinets



## Preassembled turnkey solution - ready for start up from factory



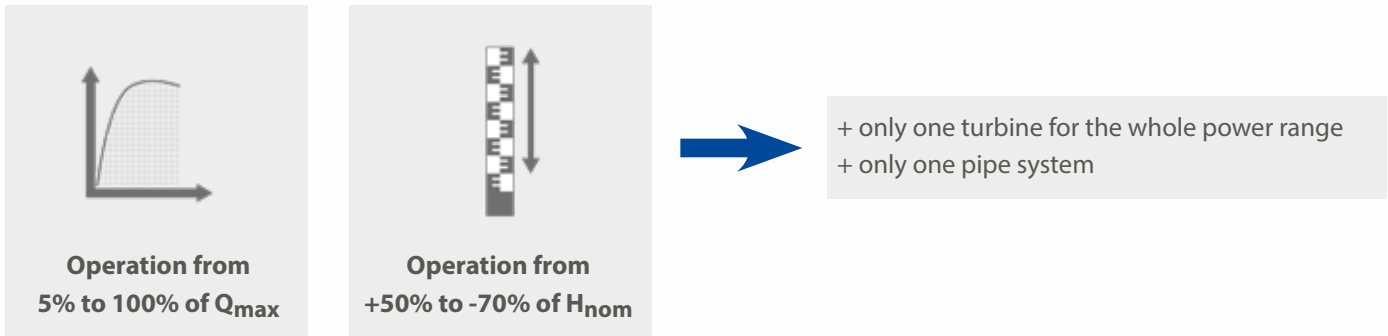
The complete unit of turbine and generator is assembled and pretested at the factory in Germany. Also the electronic equipment and control system is connected and pretested with the turbine.

## No power house necessary



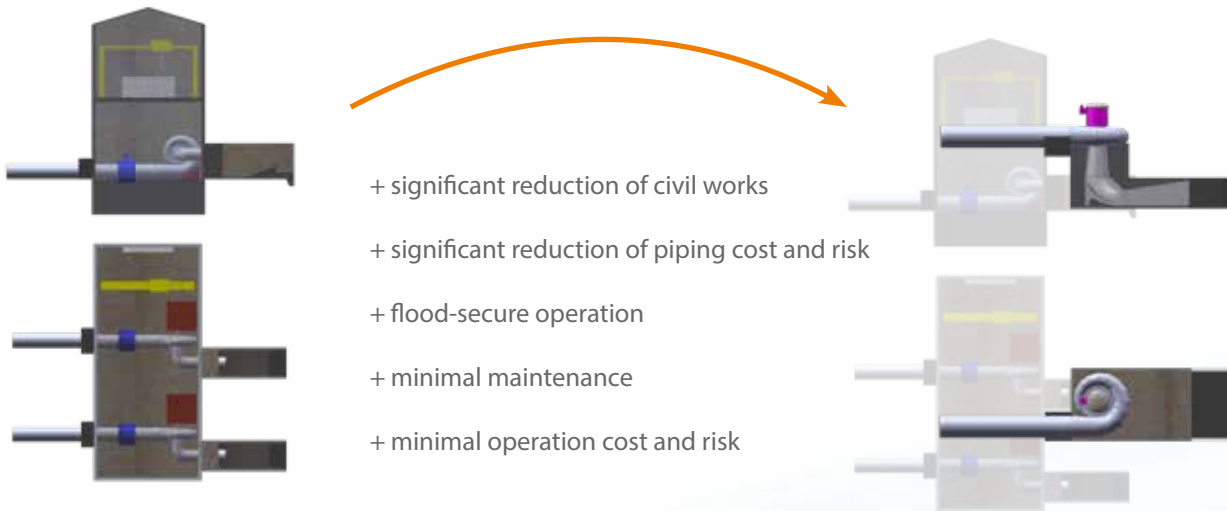
The electronic equipment and auxiliary equipment of the DIVE-Turbine is installed in a transport container. The container is used for transport and remains on site as a power house. It is equipped with a closed circuit cooling system and is therefore independent from climatic conditions on site.

# DIVE-HAX CIVIL WORKS



## CLASSICAL TWO UNIT CONCEPT

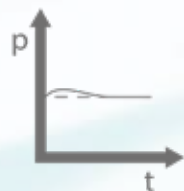
## DIVE-HAX SINGLE-UNIT CONCEPT



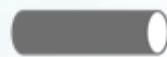
# DIVE-HAX PIPING



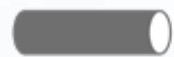
**DIVE-HAX**



closing time > 5 minutes -  
no water hammer



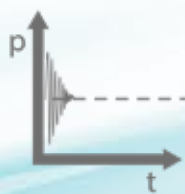
pipe design  
for 1,2x operation pressure



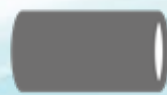
no closing valve necessary



**FRANCIS-TURBINE**



closing time < 10 seconds  
significant water hammer



pipe design for  
multiple operation pressure  
(positive and negative pressure)



butterfly valve necessary

# BENEFITS OF DIVE-HAX

Characteristics	Technical benefits	Benefits for operator and owner
Compact turbine and generator unit completely waterproof	<ul style="list-style-type: none"> <li>+ No turbine house required</li> <li>+ Minimum cost of civil works</li> <li>+ Safe operation in flood-areas</li> </ul>	Reduced investment
Direct-drive, free of mechanical transmission	<ul style="list-style-type: none"> <li>+ Minimum noise and vibration</li> <li>+ Free from maintenance and free from wear and tear</li> <li>+ No gearbox or belt-drive losses</li> </ul>	Hydropower in residential areas
Single bearing unit for turbine and generator	<ul style="list-style-type: none"> <li>+ Permanent lubrication of bearing unit in oil bath</li> <li>+ Leakage of lubricants (oil) impossible</li> <li>+ No danger in cases of runaway speed and grid interruption</li> </ul>	Minimum operational cost and risk
Wear and tear free sealing system	<ul style="list-style-type: none"> <li>+ No necessity of a costly sealing system</li> <li>+ Free from maintenance and free from wear and tear</li> <li>+ Safe operation in saline and dirty water and high load of sediments</li> </ul>	Maximum technical availability and no risk at flood situations
Fixed runner blades	<ul style="list-style-type: none"> <li>+ No maintenance and wear-intense pitching of the runner</li> <li>+ Runner design optimized for max. efficiency</li> <li>+ Zero-gap and minimal abrasive operation</li> </ul>	Minimum operation cost and risk Maximum technical availability
Double regulation by variation of speed and pitching of the guide vanes	<ul style="list-style-type: none"> <li>+ High efficiency at part-load (reduced flow and changed head)</li> <li>+ Single machine solution for medium head</li> <li>+ Discharge from 5% to 100%</li> </ul>	Maximum annual revenue with a single machine solution
Critical components made of stainless steel	<ul style="list-style-type: none"> <li>+ High resistance against wear and corrosion</li> </ul>	High durability of the main components (e.g. runner and guide vanes)

## Power Plant Calvière - Proven Technology

The project is located in Calvière, Southern France. The DIVE-HAX is replacing a Francis-twin turbine.

