

Modular pump turbine for efficient regional energy management

Stabilisation of medium-voltage grids – highly efficient and cost-effective

The electricity market is being affected by increasing load and price fluctuations. Growing electricity consumption – including for electric mobility and ICT – is coming up against more widespread decentralised energy generation from wind and sun power, which can be subject to major fluctuations.

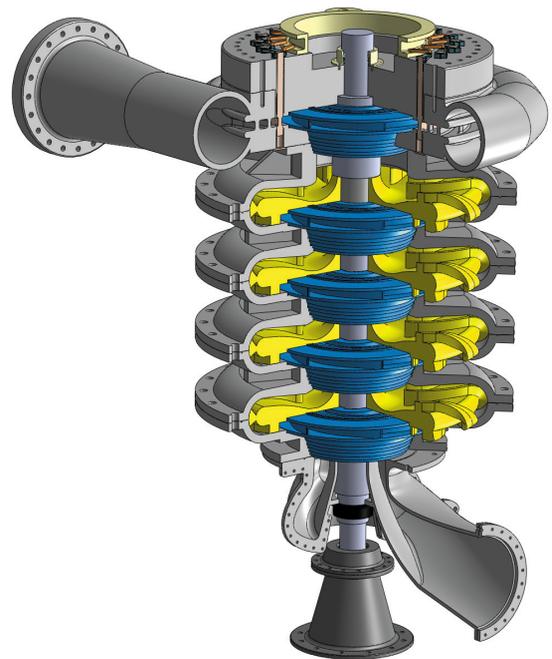
Grid operators are facing ever greater challenges to stabilise their networks. Attempts are being made to counter load fluctuations and supply bottlenecks by expanding electricity networks. At the same time, major consumers and all electricity suppliers are encountering highly fluctuating electricity prices that are difficult to predict, and are searching for flexible storage options to minimise their risks. Cost-effective, fail-safe storage technologies are needed to keep regional grids for electricity supply stable, to buffer decentralised power fluctuations and to improve the cost or revenue situation. Besides new systems such as battery farms, advanced pumped storage technology is particularly well suited to this. However, this technology has only been cost-effective to date when used on a large industrial scale. This also means it is located mostly in distant regions, as a result of which long power lines are required, which cause substantial costs and energy losses.

Objective

The objective of Professor Eduard Doujak and Professor Christian Bauer at the Institute of Energy Systems and Thermodynamics at TU Wien was to develop a distributed pumped storage system that could also guarantee stable grid operation in the low-voltage and medium-voltage ranges, even with increasing volatility, without primary dependence on higher voltage grid levels. There is enormous potential for the 0.5 MW to 15 MW range if machine manufacturing costs can be lowered.

Approach

Pumped storage plants in the low power category of 0.5 MW to 10 MW can function as short-term storage and store energy within a few minutes, or feed the stored energy back into



the grid. In terms of the reservoirs required, snow reservoirs can be used in the Alpine region, disused mines can be used in former mining regions, and fire protection ponds or other water reservoirs or existing high-pressure plants can be utilised in other areas.

Current large-scale systems in pumped storage power plants can be operated efficiently and cost-effectively by customising the configuration of the machines, which are designed according to local conditions and manufactured individually as a single piece. When it comes to lower power categories, customised design and production generates disproportionately high costs. A way to reduce these costs needs to be found.

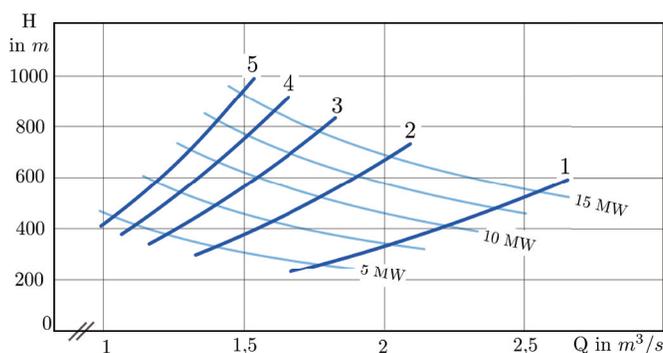
A completely new pump turbine concept has been developed at TU Wien to this end. The developers opted for a modular design, both on the hydraulic side and the electrical side, allowing cost-cutting series production and consequently greatly reducing the electromechanical investment costs for the realisation of a plant. This design allows the system to be tailored optimally to local conditions.

The customised machine unit is made up of the necessary number of standardised modules and is adapted to local requirements or adjusted to the power required for the particular regional energy management.

- By varying the number of pump turbine modules, the system can be adapted to the head in question – and therefore to the hydraulic power range.
- The number of motor/generator modules adapts the electrical machine to the required pump/turbine power. This is done by selecting the appropriate number of rotor/stator discs.
- The machine speed required for the flow rate can be achieved by procuring suitable frequency converters – which are commonly used in wind power and photovoltaics and thus commercially available in lower power categories.

Results

A series of specific case studies is available on possible application locations and scenarios for the cost-effectiveness of TU Wien's modular pump turbine. Preliminary studies have been completed and the available simulations for the hydraulic component, as well as the calculations for the electrical component, are allowing the first machine to be designed in detail and produced for field use quickly (timeframe of roughly 12 months).



Characteristic curves for different module numbers

An experienced industry partner who decides to produce a modular set of pump turbines can expect to have his product ready for market within roughly two years.

Users of the TU Wien system can expect overall efficiency of approx. 70% to 80%, with more specific numbers being possible for each local constellation by simulations available from TU Wien.

Users and applications

- grid operators and utilities
- water management, power generation, mining
- builders and operators of wind power or photovoltaic plants
- industry with highly fluctuating electricity demand or with potential to deliver electricity
- regional and urban planning
- use of existing reservoirs for energy management – e.g. fire water ponds
- use of old mines for hydraulic energy storage
- retrofitting and upgrading of existing high-pressure hydropower plants

The benefits for you

- flexible storage for volatile electrical energy from 0.5 to 15 MW
- system efficiency of 70–80%
- short reaction time: just a few minutes between electricity storage and supply
- can be combined with all forms of renewable energy

Wanted

Grid operators and utilities who are in need of regional management of volatile energy and who are interested in making use of TU Wien's patented system. Innovative pump and turbine manufacturers are also welcome.

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