Flexible hydropower ensures the security of electricity supply - Growing challenges due to accelerated climate targets and energy crisis

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ABSTRACT: Based on the study "Status and Future of Alpine Hydropower", the Working Group Alpine Hydropower (Arbeitsgemeinschaft Alpine Wasserkraft, AGAW) published the subsequent study "Hydropower & Flexibility, the contribution of Alpine hydropower to the success of the energy transition" in late 2019. As a result of the rapidly progressing climate change and the increased efforts to achieve the climate goals, the EU and its member states have agreed on fast implementation strategies following the European Green Deal. At the same time, there were rapid upheavals in the energy market due to unexpected geopolitical changes in 2022, resulting in the energy crisis.

With the focus on the updated expansion targets according to the national energy and climate plans, the increased flexibility requirements of hydropower are described. With the increasing expansion of volatile power generation from wind energy and photovoltaic systems, power generation will be subject to even greater fluctuations in the energy grids system in the future. Actually a lack of flexibility in power generation is ensured, at least temporarily, from gas-fired power plants, until there is a sufficient supply of regeneratively produced hydrogen. Nowadays, this option must be reconsidered with the increasing uncertainty in the supply of natural gas. The resulting lack of flexibility can only be compensated for by increasing the share of pumped storage.

Thus, in order to ensure the necessary balance between electricity generation and consumption in the energy transition towards a CO2-neutral future, the expansion of energy storage is also absolutely necessary. Pumped storage power plants hold a prominent position among electricity storage technologies because of their large-scale and proven application. The possible contributions in this regard and the potentials that need to be realized in the Alps are described. In addition, the possibilities and advantages of pumped storage for future requirements in terms of control energy, frequency control and the capacity market are presented. Implemented examples of how this flexibility can be provided today are highly modern pumped storage power plants, whose enormously flexible technical capabilities are demonstrated (e.g. AT: Kopswerk II, Obervermuntwerk II, Kühtai I + II, Limberg II, Reisseck II, CH: Grimsel 2, Linth-Limmern, Nant de Drance, Veytaux, FR: Bissorte, Grand-Maison, Le Cheylas, Montézic, IT: Edolo, Entraque, Ponale, SLO: Avče).

The production of flexible energy causes frequent changes in discharge, i.e. hydropeaking. In order to mitigate the effects of hydropeaking comprehensive research projects were carried out especially in Austria and Norway – from process understanding towards the development of sustainable measures. In order to reduce the ecological impact of hydropeaking, measures such as hydropeaking diversion HPPs, retention basins as well as operational measures (combined with hydromorphological measures) are foreseen according to the implementation of the Water Framework Directive (WFD) and corresponding River basin management plans (RBMPs). Regarding hydropeaking diversion HPPs the project GKI has pilot character in the alps. Regarding retention basins, examples from Austria (Silz, Inn river), Italy (St. Anton, Talfer) and Switzerland (Innertkirchen, Hasliaare) represent best practise. Operational measures can include the use of impoundments to buffer hydropeaking waves. Other operational measures at flexible HPPs are not feasible, as flexibility of hydropower ensures the integration of “new renewables” (wind, PV) and are the key factor for successful energy transition.

Regarding pumped storage power HPPs the advantage is, that they can be also operated as a closed system, i.e. turbining/pumping from an upper to a lower stage and backwards, which reduces hydropeaking towards receiving waters. However, storage hydropower with high heads might be not feasible for pumped storage and require suitable hydropeaking mitigation. The case studies presented herein, underline that the hydropower sector develops suitable measures to ensure energy security and sustainable operation of hydropower plants.