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Four decades of hindsight into a complex hydropower system

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Hydropower systems often operate in contextual conditions quite different from those for which they have been planned for. Often, the pace at which the changes occur does not invite operators to analyse their long-term effects and quantify the resilience of these system.

During the last decades hydropower has experienced strong changes. Energy markets have evolved, dam safety guidelines and legislations have undergone improvements, societal awareness towards their potentially adverse effects on natural ecosystems has risen, and recent technologies have made their way into the energy market. Renewable sources of electricity such as solar and wind, though competing with hydropower, also came to highlight the key role that storage reservoirs have in transferring energy from periods of high electricity production (and water availability) to periods of high electricity demand (and water scarcity).

In the next decades, hydropower will have to cope with climate change, new environmental regulations, the increasing growth pace of non-dispatchable renewables, and increasingly dynamic energy markets. Identifying and describing how hydropower systems have been operated in the past under different context conditions may provide valuable insights into how they can best be explored to meet future challenges.

With the end goal of better informing future management decisions, the present work looks at the history of the KWO system since the 1980's to the present day. The KWO hydropower system is located in the mountains of the Bernese Alps. It counts 9 power plans with 26 turbines adding up to an installed capacity of 1125 MW. Amidst several lakes, it includes four major reservoirs. The system is highly interconnected and is equipped with significant pumping capacity, features that grant it substantial flexibility to adapt its operating strategies. The average annual energy production of KWO is 2350 GWh. A detailed analysis of this system is interesting in two main ways. First, it is very well monitored and, therefore, makes a wealth of relevant data available. Second, Swiss hydropower will very likely benefit from good opportunities and face significant challenges in the future: on the side of water availability, in the course of the next decades climate change will have a positive impact on hydropower production as the water stored in the receding glaciers becomes available for energy production; on the side of demands, with expectations of increasingly dynamic electrical markets in Europe and changes in the energy mix of Switzerland and its neighbouring countries (notably drifting away from nuclear and strengthening wind and solar energy sources).

With the benefit of hindsight, this study uses clustering techniques to identify and quantitatively describe the main modes of operation that were followed historically in the KWO system, putting them into context with information about market conditions and hydrology.