D-HYDROFLEX: digital hybridisation for more flexible hydropower

D-HYDROFLEX demonstrates how digitalisation can extend beyond monitoring and predictive maintenance and become an active tool for increasing the flexibility of hydropower plants. One example is HYDRO-SDS (Smart Decision Support), developed to support the coordinated operation of hydropower together with complementary renewable generation, hydrogen technologies and electricity grids.

This type of hybridisation becomes increasingly relevant as power systems integrate larger shares of variable renewable generation. Different renewable resources are available at different times and under different operating constraints, while energy can also be managed through different vectors, such as electricity and hydrogen. Hydropower has significant potential in this context: depending on the characteristics and constraints of each plant, it can provide a controllable renewable backbone around which other variable generation and storage technologies can be coordinated.

HYDRO-SDS uses a modular architecture developed at a high level in Python. Instead of treating the hydropower plant as an isolated electricity generator, the tool combines information on expected water availability and hydropower production with photovoltaic generation, hydrogen production and storage, electricity-market signals and local grid requirements. Based on these inputs and the technical operating constraints of the different components, HYDRO-SDS generates an operation plan that supports the plant operator in deciding how the available renewable resources should be used.

The concept allows electricity from hydropower and PV to be coordinated with a power-to-hydrogen pathway, providing an additional option when direct electricity injection is limited or less favourable. The hydrogen produced can be stored and later converted back into electricity through a hydrogen-to-power pathway, or it can be considered as a final energy product and sold directly when this represents the preferred operational or economic option. Hybridisation therefore adds an additional degree of freedom to the plant, allowing electricity generation, storage and hydrogen production to be managed within the same decision-support framework rather than as separate systems.

Within D-HYDROFLEX, HYDRO-SDS is applied in two hydropower demonstration environments with different technical characteristics: Salto de Touro in Spain, a run-of-river plant equipped with two vertical-axis Kaplan turbines, and Bratia in Romania, a river-flow plant equipped with two Pelton turbines. Applying the same modular decision-support concept to these different hydropower technologies illustrates its adaptability to different plant configurations and operating conditions.

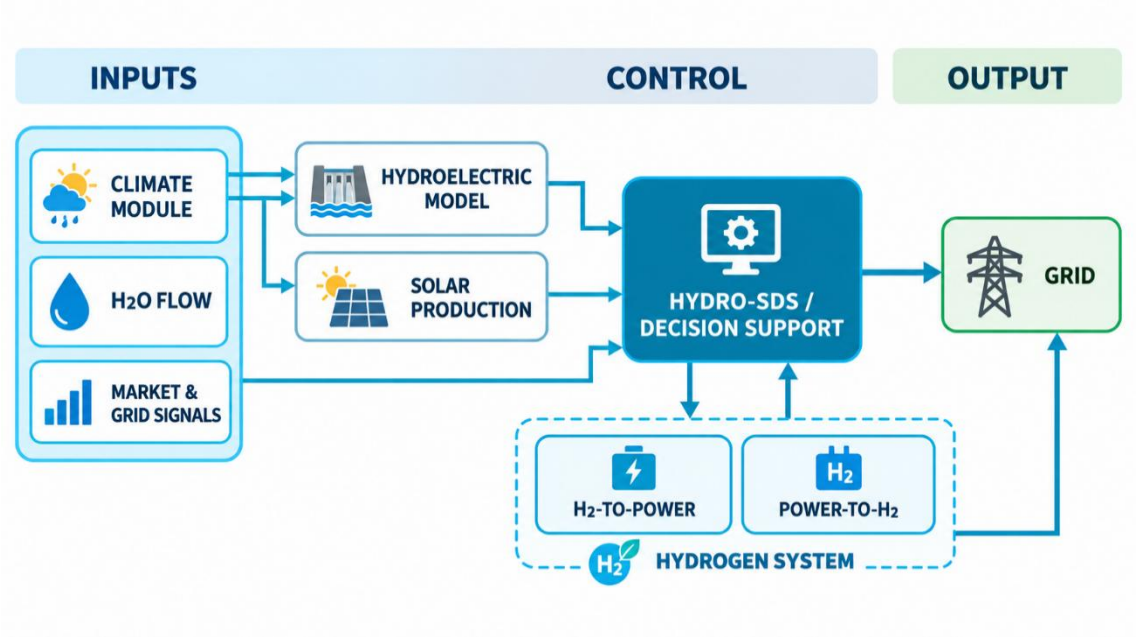

Figure 1: Scheme of the SDS concept

This example illustrates a wider role for digitalisation in hydropower: not only making existing plants more observable, but enabling them to become active nodes in increasingly integrated energy systems, where renewable generation, storage, hydrogen, electricity markets and grid requirements can be coordinated. Continued European support for demonstration, interoperability and replication will be important to move these solutions from project-level developments towards wider deployment across the European hydropower fleet and, potentially, markets beyond Europe.