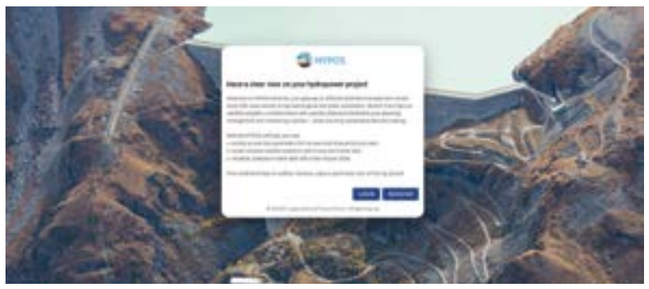
Satellite sediment management

HYPOS is a new toolbox that enables sediment management to be powered by satellite technology and helps hydropower planners and managers overcome the challenges posed by sedimentation

Above: **Figure 1: The HYdro-POwer-Suite (HYPOS) subscription portal offers hydropower managers, planners and decision-makers direct access to key hydrological and water quality parameters and assessment tools.** Photo credit (c/ HYPOS Patrick De Goumoens)

Above: **Figure 2: Highly turbid waters entering the Cahora Bassa reservoir in Mozambique, indicating sedimentation issues.** (c/ EOMAP contains Copernicus data from 2020)

Below: **Figure 3: The entry point to the HYPOS toolbox** (c/ HYPOS, Stucky)



HYDROPOWER, AS THE WORLD'S largest source of renewable energy, has an essential role to play in climate change mitigation and adaptation of the energy sector[1,2]. The economic and ecological evaluation of hydropower developments rely on a number of environmental conditions, such as key hydrological parameters (eg reservoir storage capacity over time; reservoir life time) which are directly related to the sediment regime and sediment entrapment[3].

Planning the development of new, as well as the long-term sustainability of existing reservoirs can be severely influenced by sedimentation, making it one of the most pressing issues for managers and operators in this sector. More explicitly, reservoir sedimentation results in annual losses estimated to be 0.5-1 % of the total storage volume[5]. This loss of storage is higher than the increase in capacity made possible through the construction of new reservoirs, making sediment mitigation measures of vital importance for increasing the lifetime and enhancing the sustainability of existing reservoirs[3].

These factors, representing a major driver of reservoir operating costs, are defined by external environmental boundary conditions that are largely unknown during the pre-planning stage, typically due to the absence of data. In addition, for existing hydropower projects, monitoring protocols are still predominantly based on water sampling and probes at few locations, hampering the holistic evaluation of environmental conditions. Hydropower managers thus lack tools to enable impact assessments at the catchment scale, especially during the planning process when extended areas and river systems shall be investigated. The absence of these assessments can result in unexpected socio-economic, ecological and political consequences in both the short and the long-term, and cost overruns can occur due to erroneous site selection and inadequate planning[4].

Re-inventing planning and monitoring

Recognising the need for innovative solutions to combat these challenges, the EU Horizon 2020 Research and Innovation Programme has funded the HYdro-POwer-Suite (HYPOS) project, which began in Dec 2019. HYPOS is working to fill these gaps through the development of an online accessible decision support tool (Figure 3), which enables environmental and economic investment planning and monitoring based on state-of-the-art Earth Observation (EO) technologies and hydrological modelling complemented by available on-site data.

Specifically, the tool combines satellite-derived water quality parameters (eg turbidity) with key hydrological data (eg inflow-outflow volumes; discharge) that is operationally produced every day, to facilitate assessments of sediment transport and sedimentation rates within the portal. Thus, at the click of a mouse, results such as total suspended solids in the water can be depicted instantaneously for the entire catchment by the software's algorithms, provided satellite data is available.

The HYPOS consortium is comprised of five sectoral industry and innovation leaders in the fields of:

- Aquatic EO (EOMAP, Institute for the Electromagnetic Sensing of the Environment|CNR IREA).
- Hydrological modelling (Swedish Meteorological and Hydrological Institute|SMHI).
- On-site data (Norwegian University of Science and Technology|NTNU).
- Hydropower engineering (STUCKY Ltd.).

The project is led by EOMAP, a global specialist on satellite-based aquatic services from Germany. Together they form the optimal basis for developing this tool, which utilises distributed cloud computing infrastructures and full automation in scalable IT concepts that will enable the scalability and cost efficiency of data generation.

Quick and easy access

To help hydropower managers, planners and decision-makers build a more accurate and comprehensive picture of their reservoir, the HYPOS solution aims to provide easy access to key hydrological and water quality parameters for selectable time periods, covering actual, recent seasonal or historic data on demand. This will further enable the estimation of key dynamic trends at larger timescales, including long-term statistics of relevance (eg high/low monthly flows, etc, calculated using the HYPE model[6]), along with daily updates for essential hydrological variables (eg discharge, soil moisture, etc.) which may otherwise not be available.

Additional advantages of the HYPOS solution include access to spatially explicit data, continuous measurements (every several days for EO data, depending on cloud coverage; daily updates for modelled flow and sediment concentrations), and significantly lower costs than field campaigns. The absence of such data currently introduces major opportunities for cost optimisations and improved sustainability of development plans that signify an important contribution to the hydropower industry, where at present some 3700 dams (≥1MW) are either planned or under construction worldwide[7].

With HYPOS, many activities required from hydropower plant operators can be simplified, including the identification of sediment baselines and seasonal trends, monitoring of sediment dynamics, calculation of sedimentation rates and flows, and the monitoring of algal bloom evolution in reservoirs. Current satellite-based parameters included in the HYPOS portal are:

- Turbidity [NTU]
- Total Suspended Solids (after calibration with turbidity) [mg/l]
- Chlorophyll-a [µg/l]
- Surface water temperature [°C]
- Secchi disk depth (visibility) [m]

Another satellite-derived parameter that can make water managers more aware of water consumption is the estimation of water evaporated from reservoirs. This parameter, coupled with the energy demand of downstream populations, can help in the decision of best withdrawal times and make water management more efficient.

In addition, direct environmental impact changes, ie resulting from prevention and mitigation counter-measures such as flushing and/or dredging, can be monitored for adaptive planning purposes. The HYPOS solution thus signifies a game changer for the industry, enabling strategic hydropower planning so rarely applied to-date on basin scales, despite studies demonstrating that the strategic planning and operation of dams can greatly improve trade-offs between dam impacts and benefits for sub-basins[8].

Tested on European rivers

To date, the HYPOS portal has been tested on four reservoirs and rivers in Switzerland, Albania and Georgia (see Figure 4), and will go global in 2022, with the official launch of the HYPOS portal expected in April.

In Switzerland, the tool is being tested in two cases, Gebidem Dam and hydropower plant (Gebidem), as well as for the Verbois, Chancy-Pougny and Génissiat hydropower plant cascade (Rhône). For Gebidem, annual flushing is required in order to manage the sediment load, requiring the owner/operator to closely monitor sedimentation of the reservoir. The HYPOS tool will be used to identify the sources of sediment, support the monitoring of sedimentation levels, and for documenting changes in longitudinal river water quality (up- and downstream of the dam). Similarly, for the Rhone case study, sedimentation levels are currently subject to continuous monitoring, where HYPOS services will be used to monitor sediment dynamics up- and downstream of the confluence of the Arve and Rhone rivers, as well as up- and downstream of the two dams. In addition, the spatio-temporal impacts of flushing can be monitored using HYPOS services and enable a more holistic and strategic operation of the dam for improving environmental impact assessments.

Right: **Figure 4: The Banja Reservoir in Albania is one of the project case studies** (c/ Statkraft)

The Enguri and Vardnili Dam and hydropower plant cascade in Georgia represents another key use case for demonstrating HYPOS capabilities. Bathymetric surveys conducted by Stucky have shown that sediment accumulations levels in front of the dam are exceeding the sills of the low-level outlets. HYPOS will be used to determine the baseline sedimentation levels in this basin, and to provide continuous monitoring of these levels for ensuring that proper countermeasures are taken in a timely fashion, also in the event of flooding. Finally, the Banja Dam and hydropower plant located in Albania, has used HYPOS services to support the planning of an additional hydropower plant in the catchment. The HYPOS tool will additionally be used to calculate sedimentation rates for the Banja reservoir.

Get involved

On 15 December 2021, the HYPOS tool was introduced to hydropower stakeholders, demonstrating the increased accuracy and more comprehensive view on reservoirs and river catchments made possible through the portal. Additional webinars are planned in February and April 2022, where the latter represents the formal launch of the tool with its full suite of capabilities. ●

For more information about the HYPOs project, please visit https://hypos-project.eu/ or send an email to contact@hypos-project.eu.

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Right: **Figure 5: Turbidity dynamics in Banja Reservoir, Albania - based on high-resolution satellite images** (c/ HYPOS)

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