



Digital maintenance for sustainable and flexible
operation of HYDROpower plant

Di-Hydro Project Overview

4th Brussels Hydropower Day - 8th September 2026

Alkiviadis Tromaras-CERTH



This project has received funding by the European Union's Horizon Europe research and innovation programme under Grant Agreement N° 101122311

GENERAL PROJECT INFORMATION

PROJECT DURATION

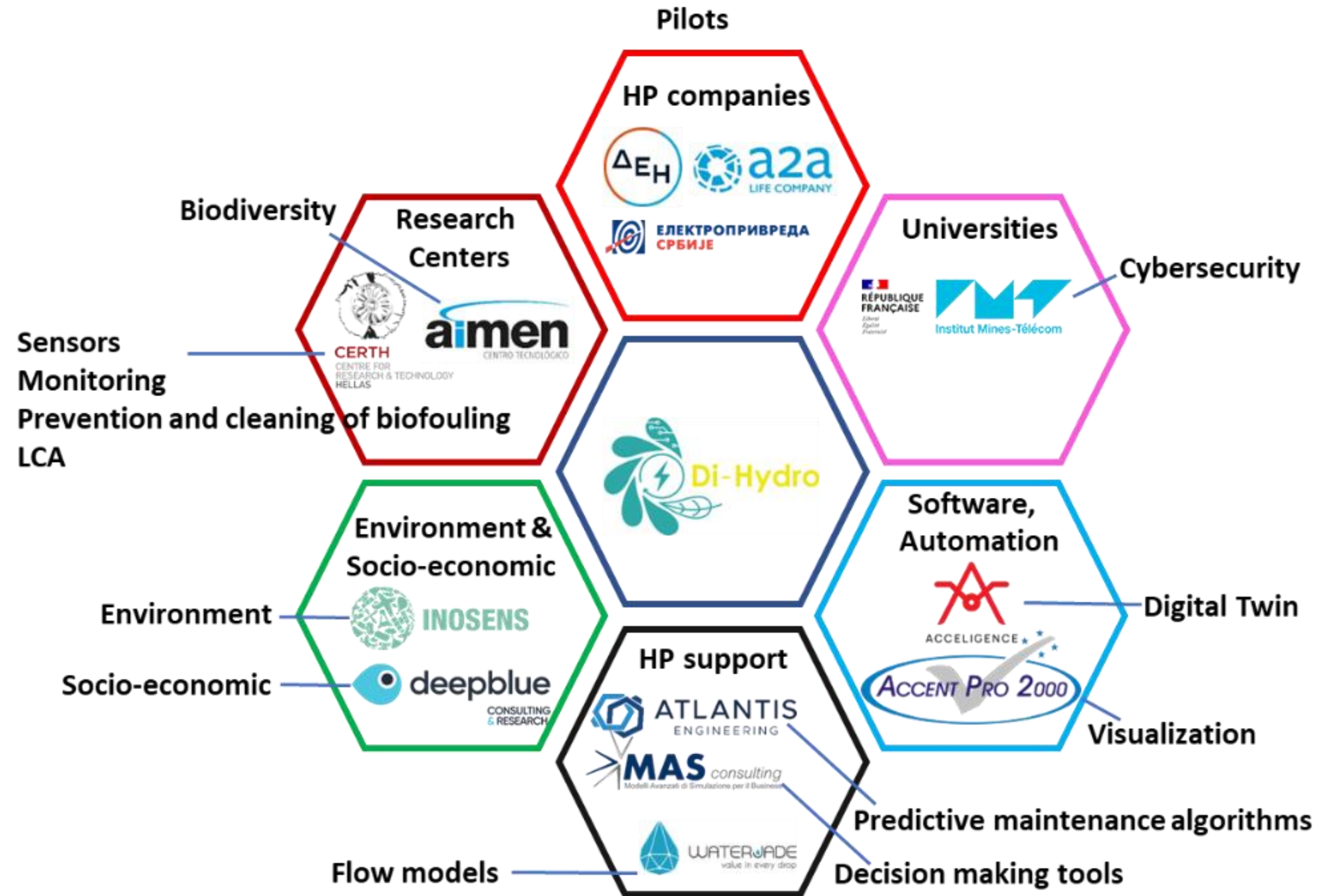
36 months - from 1/10/2023 to 30/09/2026

BUDGET

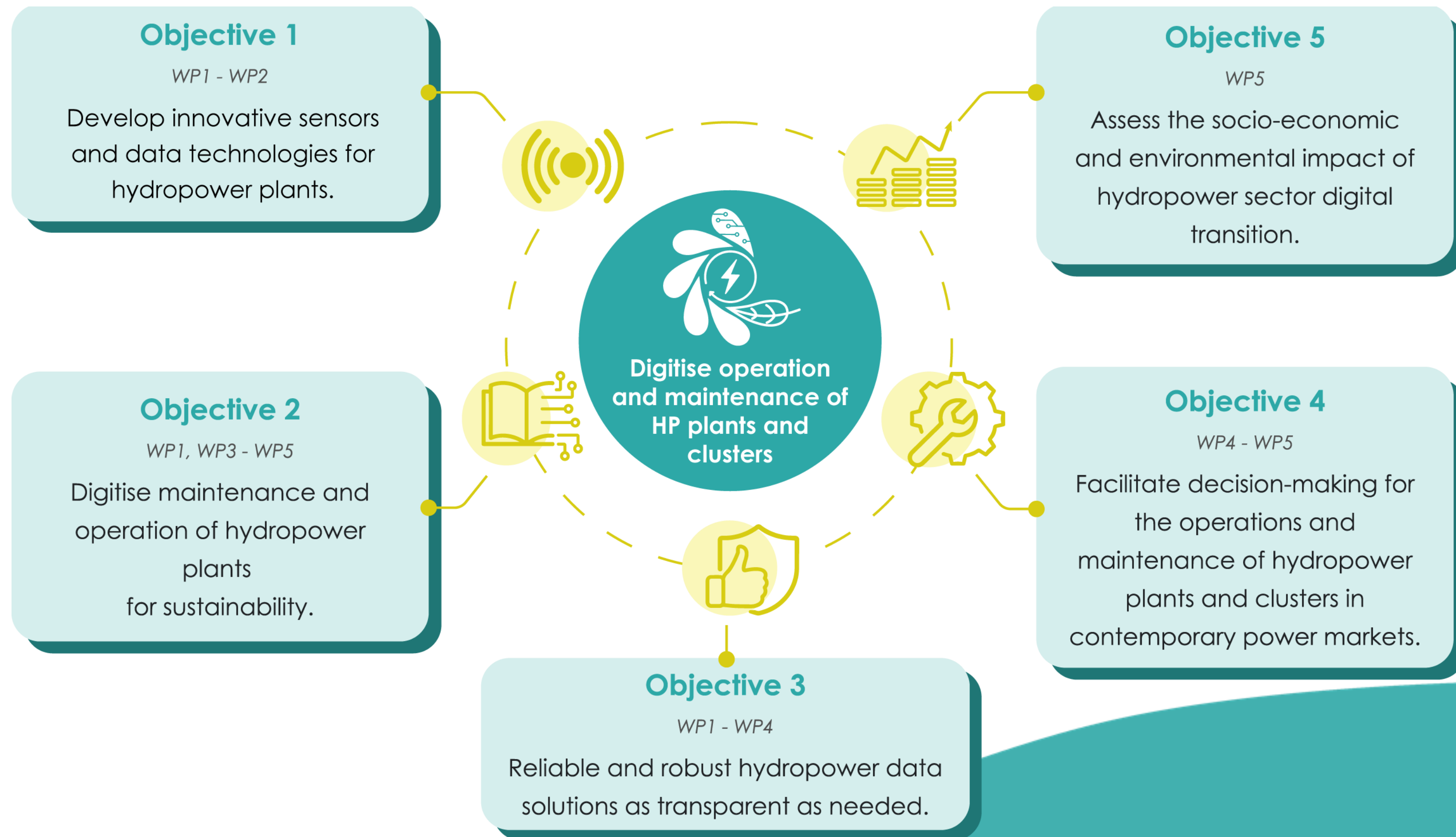
~ 4.5 M €

PARTNERS

13 partners



Project Objectives



Use Case 1 – PPC- Greece

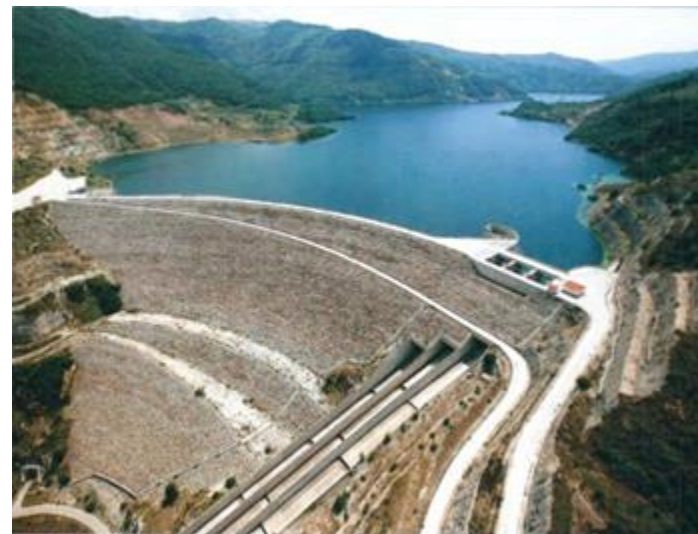
*Application of Di-Hydro DT and integration in HP digital cluster.
Calibration of Di- Hydro Decision Making Platform for HPPs and cluster*

Ilarionas HPP



Capacity: 155 MW
Turbines: 2x Francis
Storage HPP

Thisavros HPP



Capacity: 375 MW
Turbines: 3x Francis
Pumped storage type HPP

Pournari I HPP



Capacity: 300 MW
Turbines: 3x Francis
Storage HPP



LOCATIONS:



Pournari Artas
Epirus, Greece



Ilarionas Kozanis
Western Macedonia, Greece



Thisavros Dramas
Central Macedonia, Greece

Development of a modular sensor node that consists of:

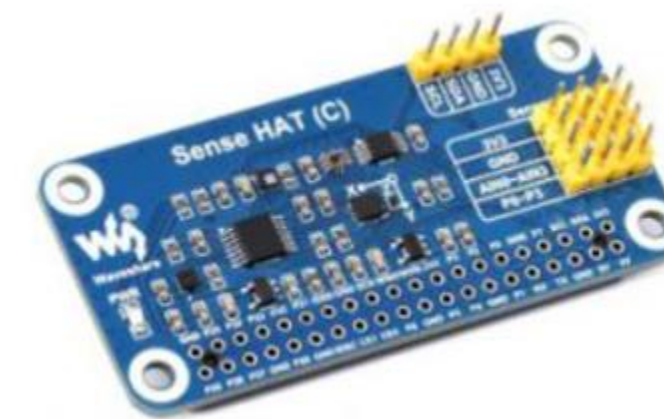
- Acoustic Emission (AE) PZT sensors and a data acquisition system for detecting flaws, cracking and damage evolution before it becomes critical.
- Accelerometers for the detection of micro vibrations resulting from cracking, flaw formation and ongoing damages in mechanical equipment and structural parts.
- Magnetometers in order to detect disruption in the magnetic flux of electric motors resulting from worn components.
- Integrated temperature sensor and humidity sensor to monitor the conditions of the operation environment.
- Crack growth sensor to detect crack growth on structural parts.



Data acquisition and wireless data transition AE system



AE sensor



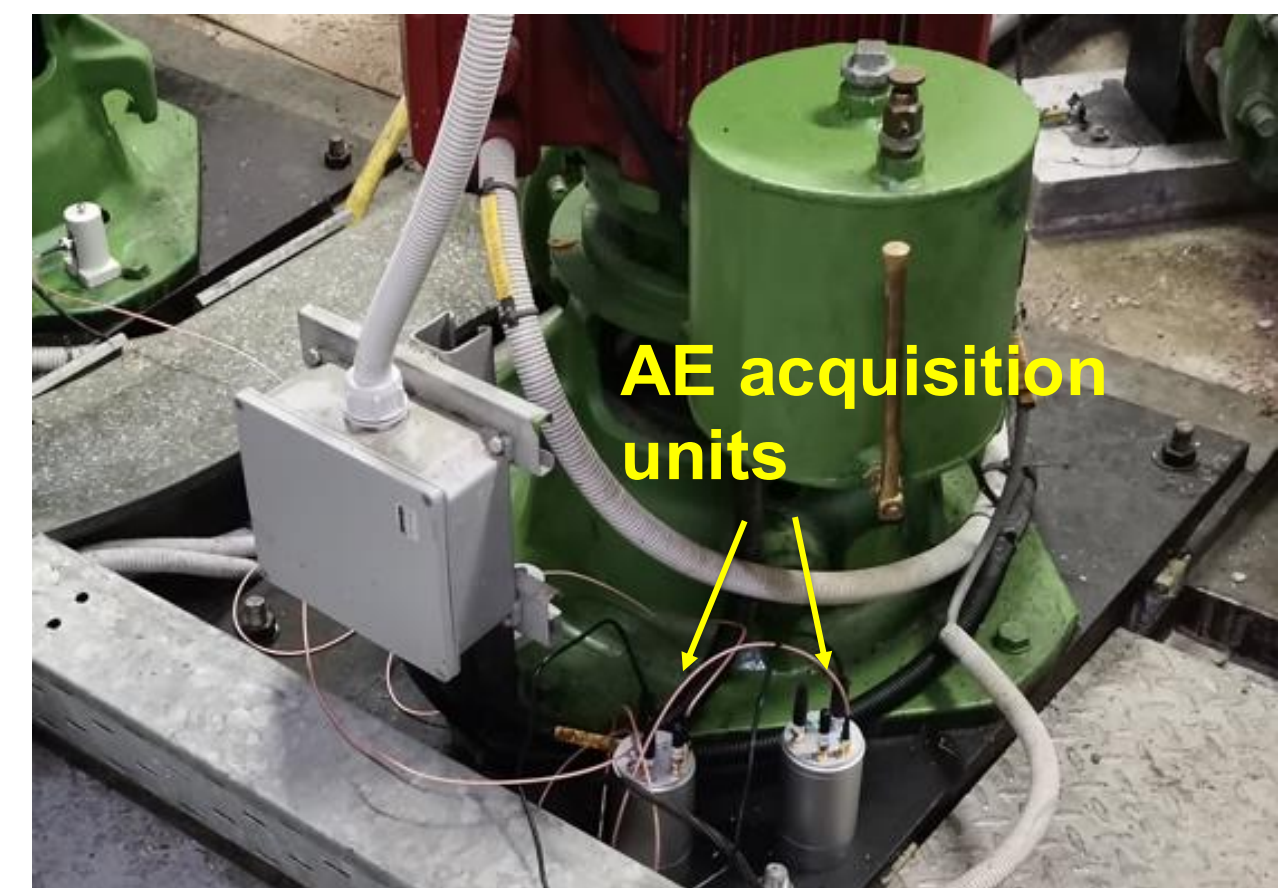
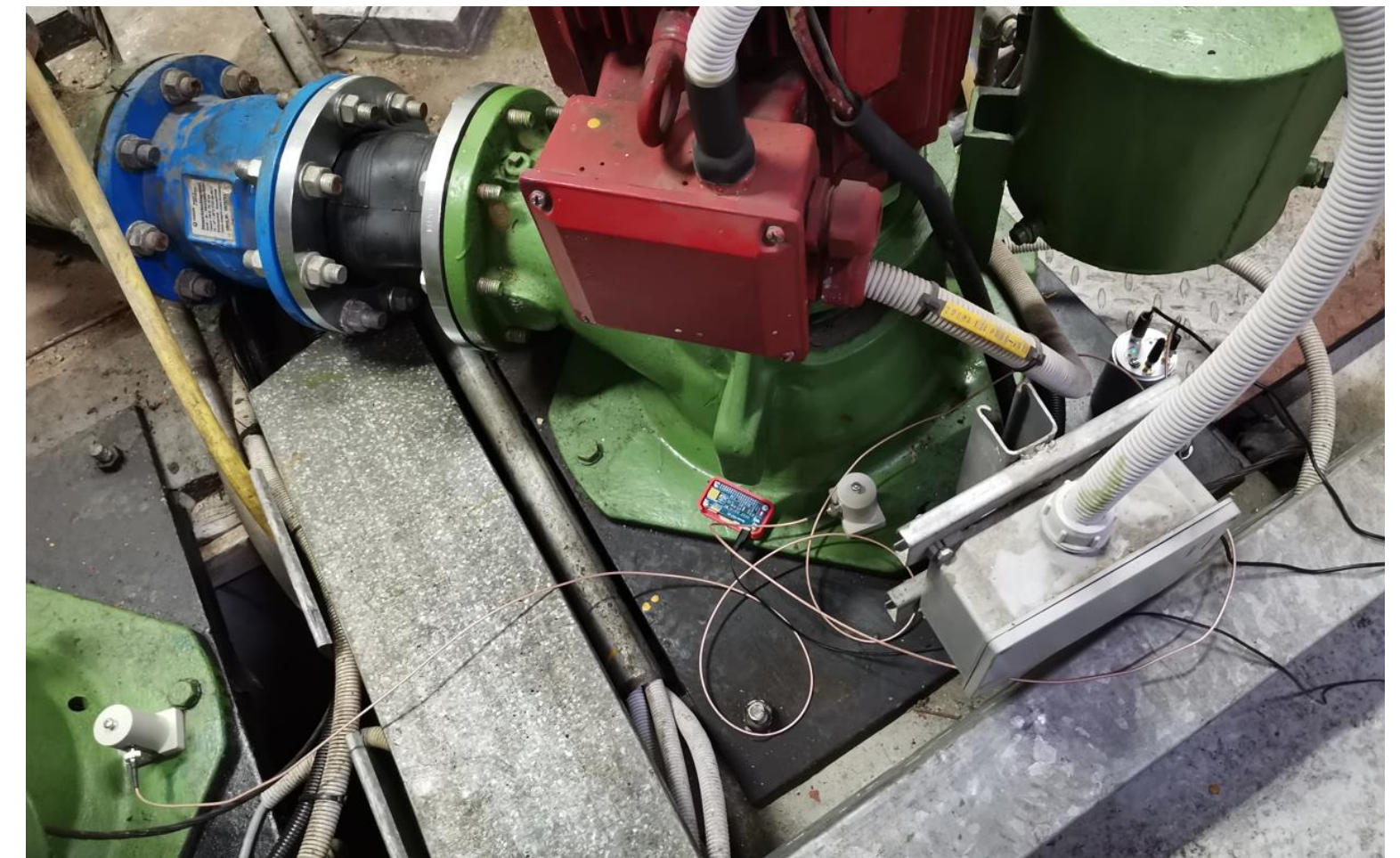
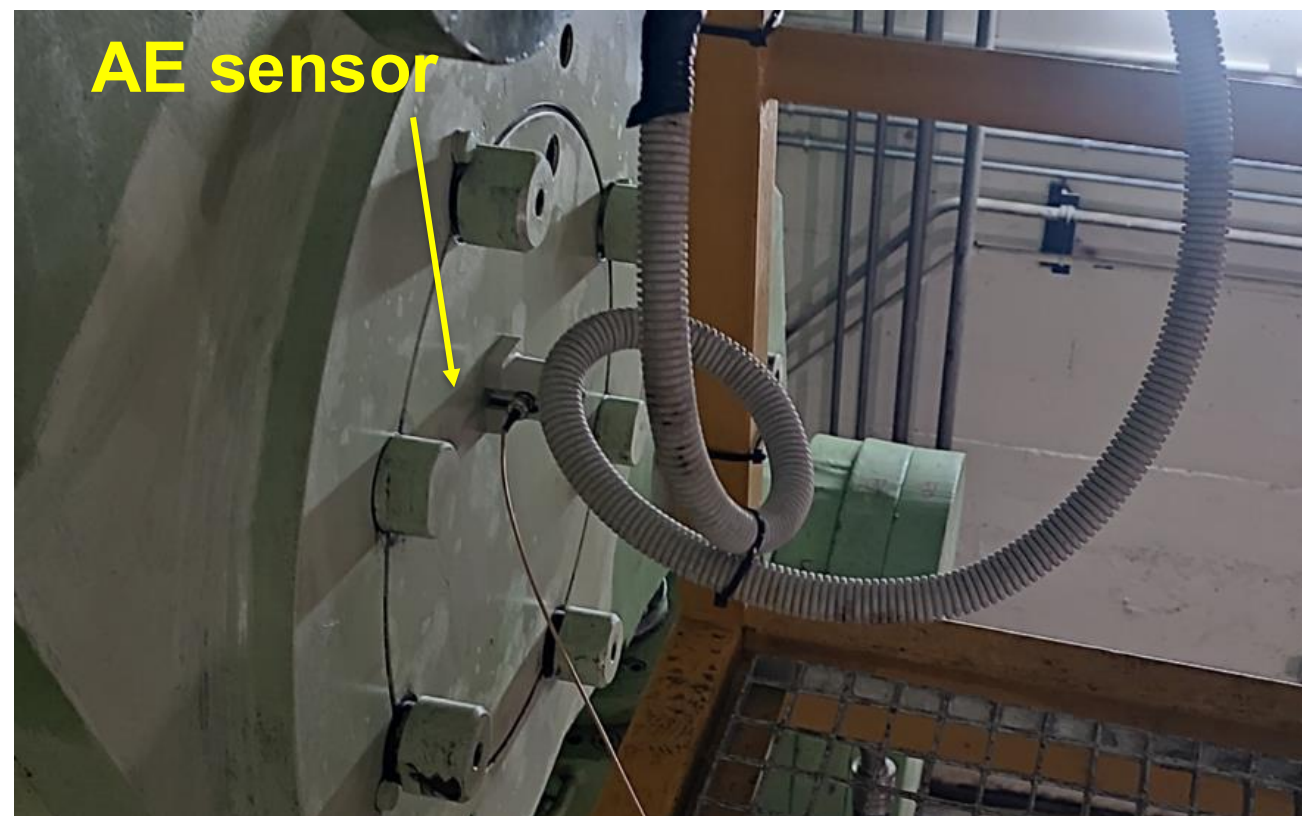
Integrated sensor module



Crack growth module

Task 4.1 Deployment and performance assessment of stand-alone HPP O&M pilots

SHM / CM sensor node for HPP machinery and infrastructure



Predictive analytics - enable maximum performance of the HP O&M.

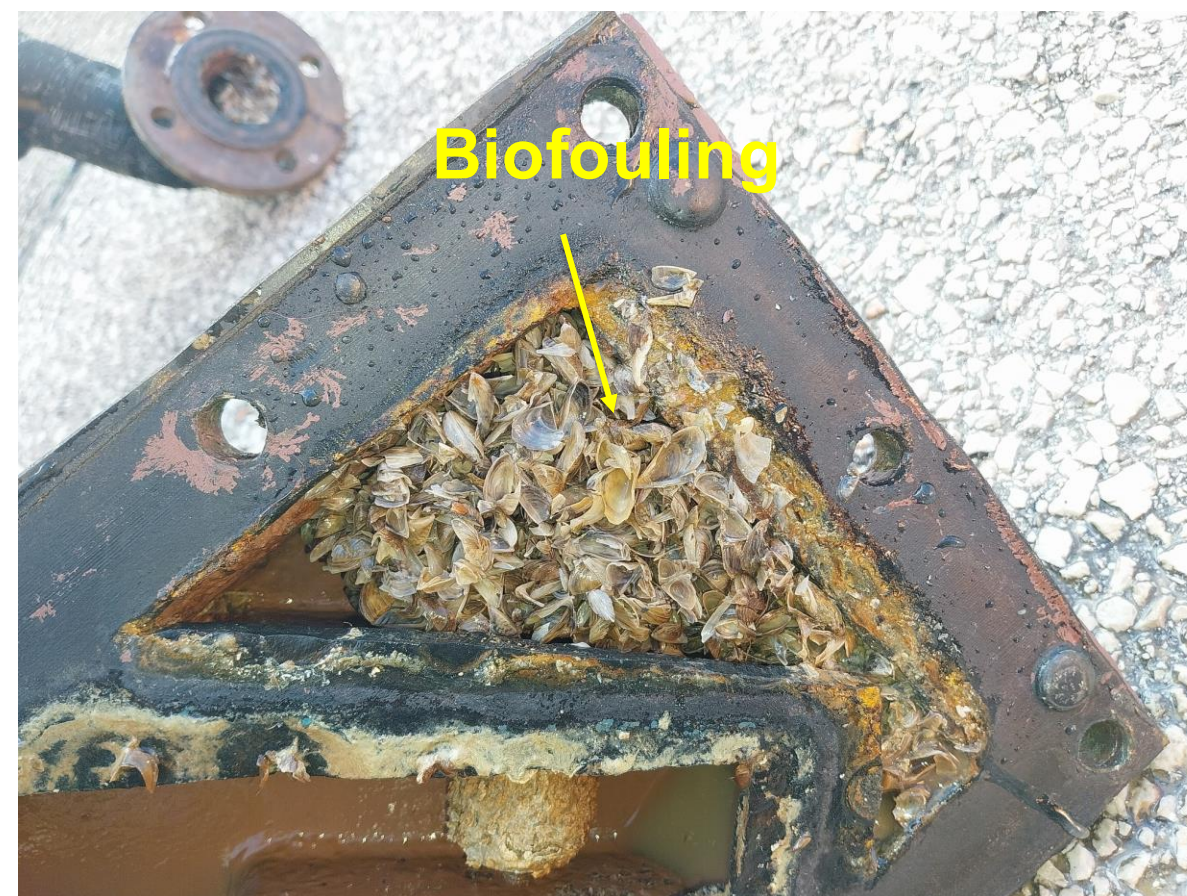
- **Available data** (i.e., sensorial, historical, live, metadata) were **analyzed** by novel **ML/AI models** to identify and predict various trends in the HP
- Models were trained on labelled lab data and on-site data to **detect** and **identify** failures on motor's drivetrain
- A **fusion** mechanism was developed to combine the various models' outcomes to a more robust detection output
- An unsupervised model was trained on the data received from PPC plant in Ilarionas for the temperature anomaly detection on the stator core



Ilarionas Kozanis
Western Macedonia, Greece

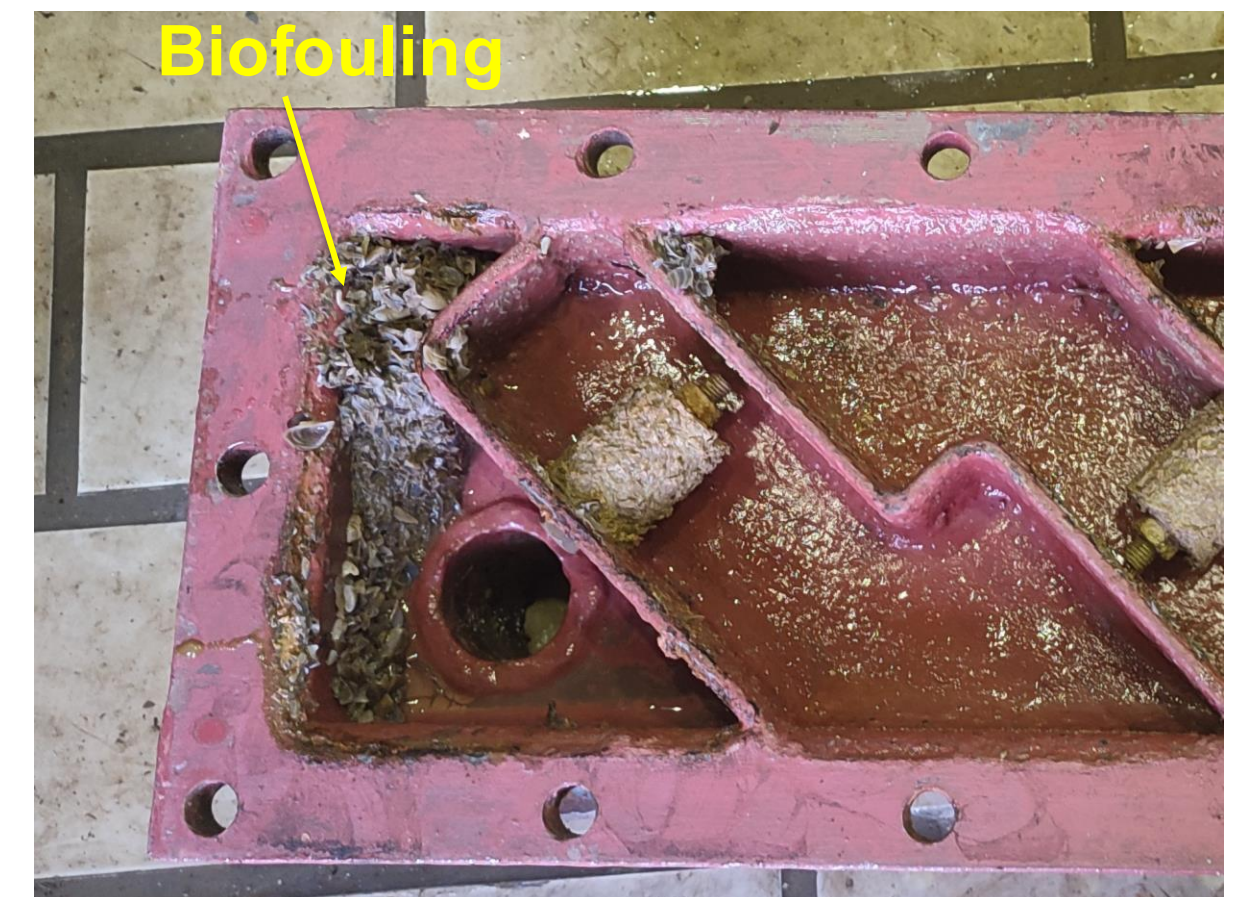
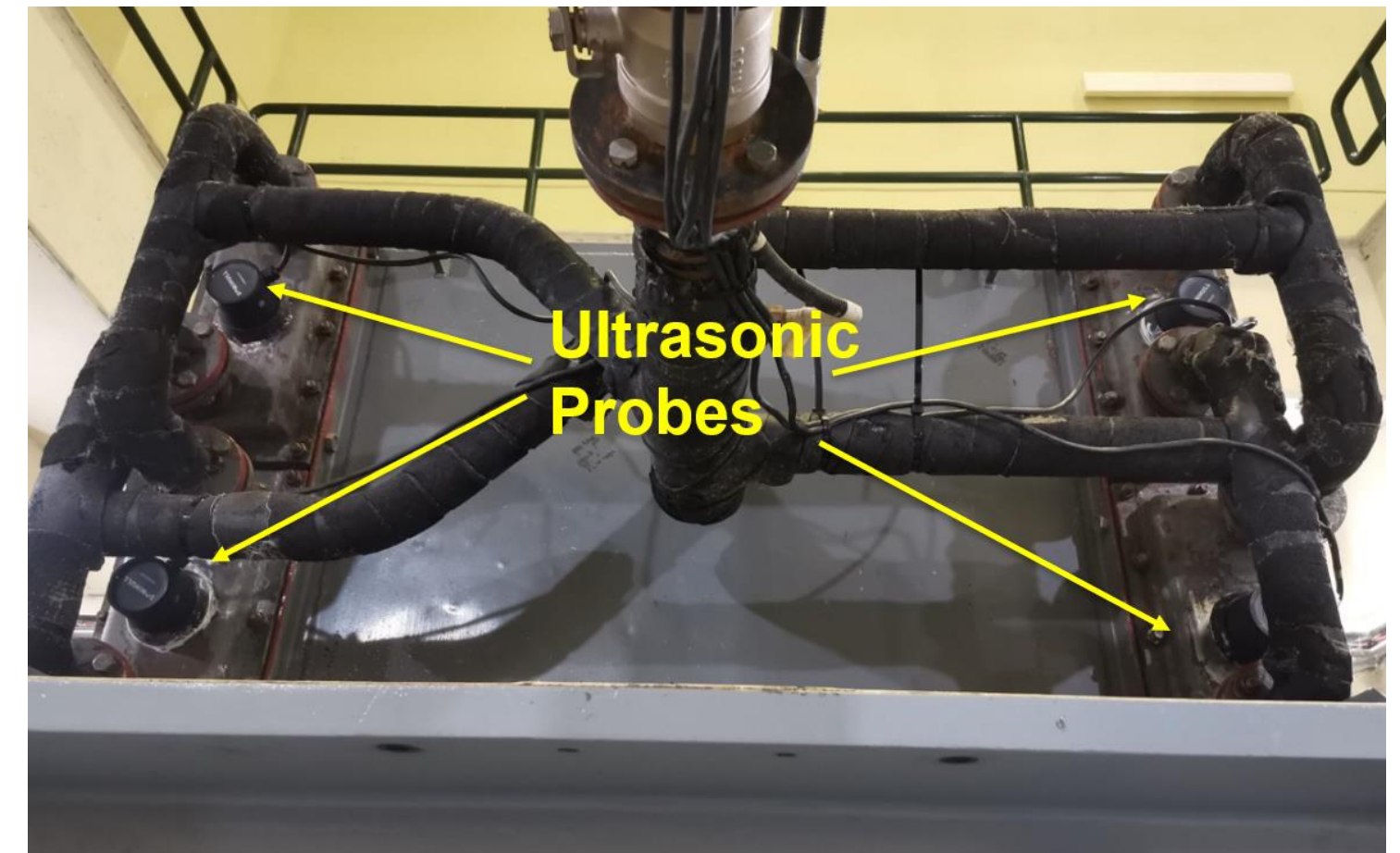


- Tested the effectiveness of ultrasonic based antibiofouling system under lab and real-life conditions
- The antifouling system creates micro-cavitation that disrupts algae formation on surfaces
- Portable and easy to install
- The anti-fouling does not cause damage on surfaces and components
- Suitable for heat exchangers and piping



Before

Ultrasonic Anti-biofouling unit



After

- Visual inspections of water reservoir foundations using advanced and highly maneuverable ROV
- 2 stage approach
 - Underwater Image Enhancement / Preprocessing
 - ML Based Damage Detection

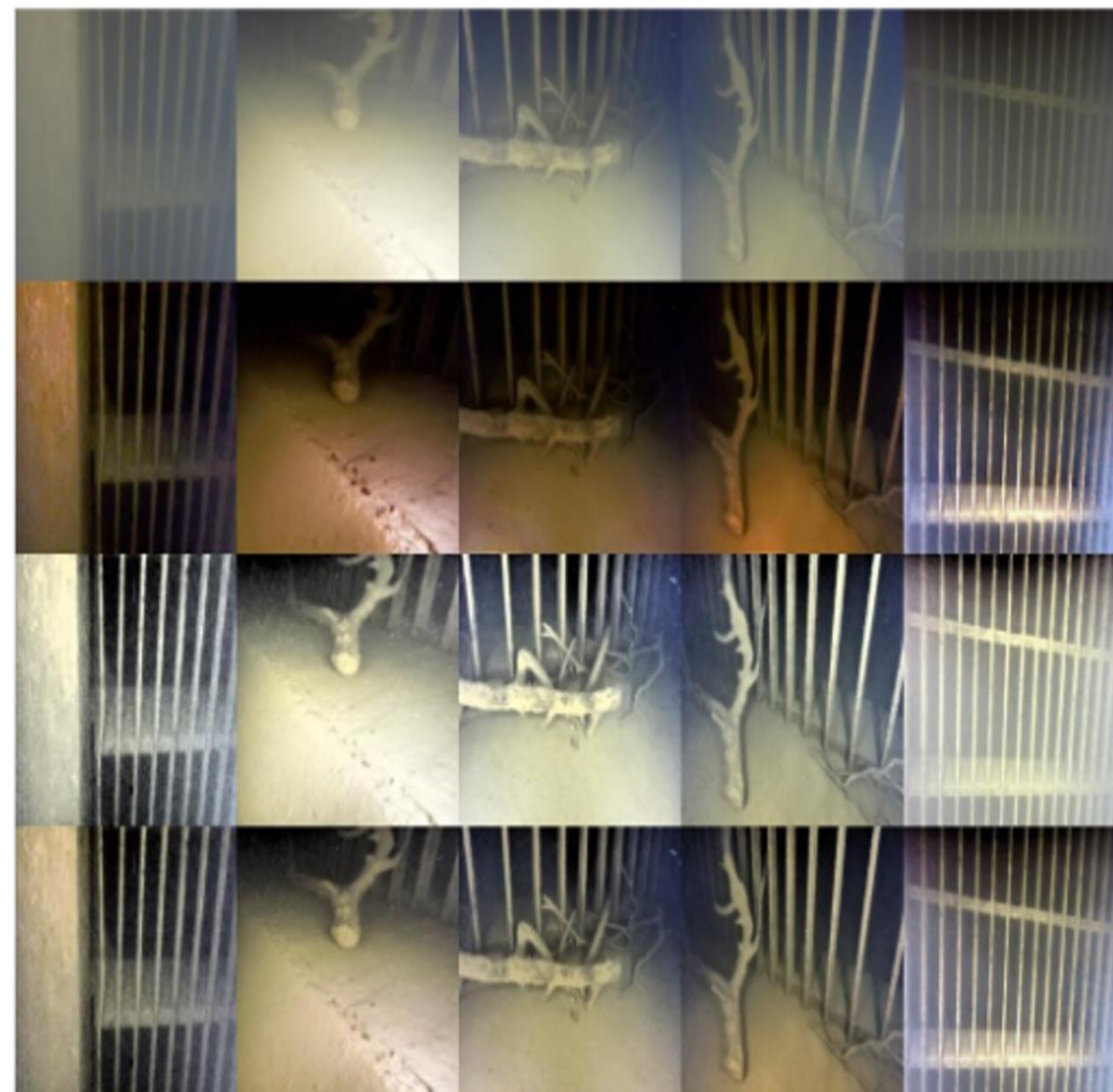


Original

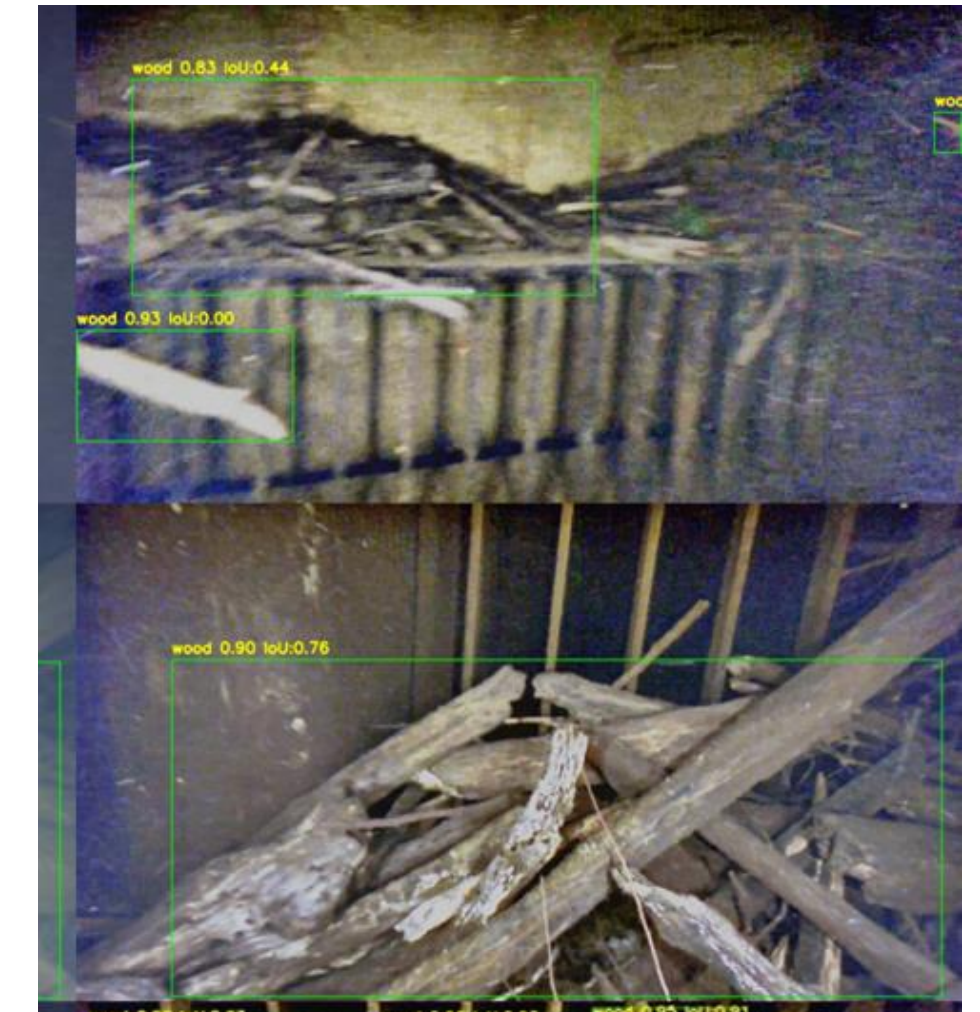
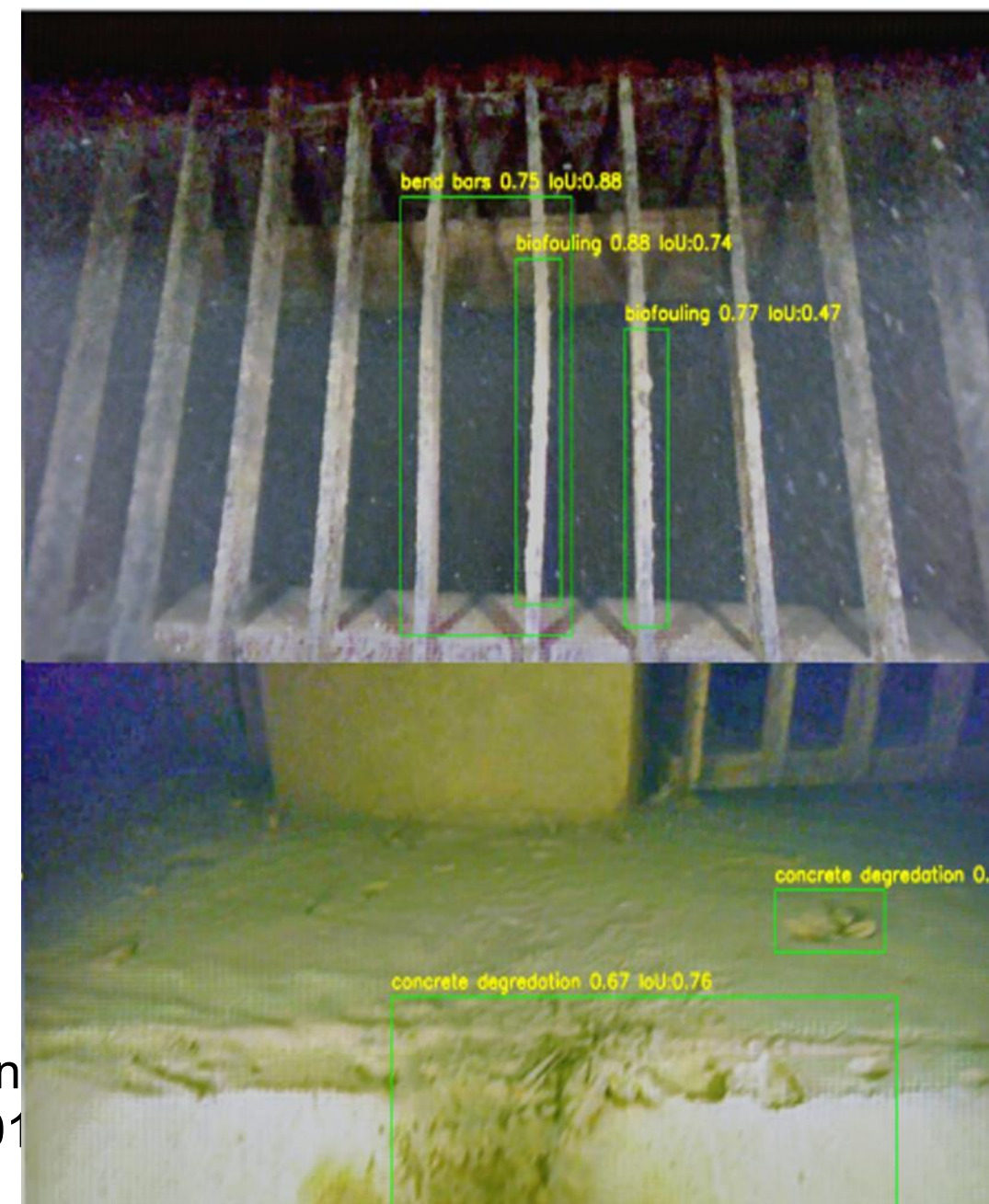
CycleGAN

Retinet

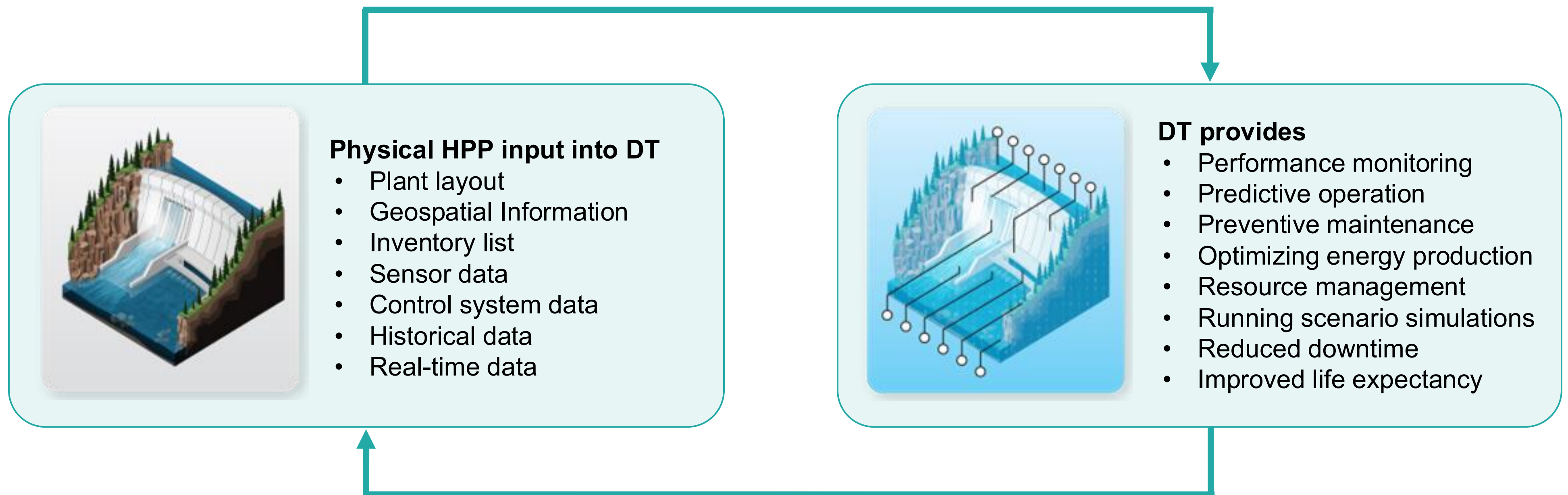
Fusion

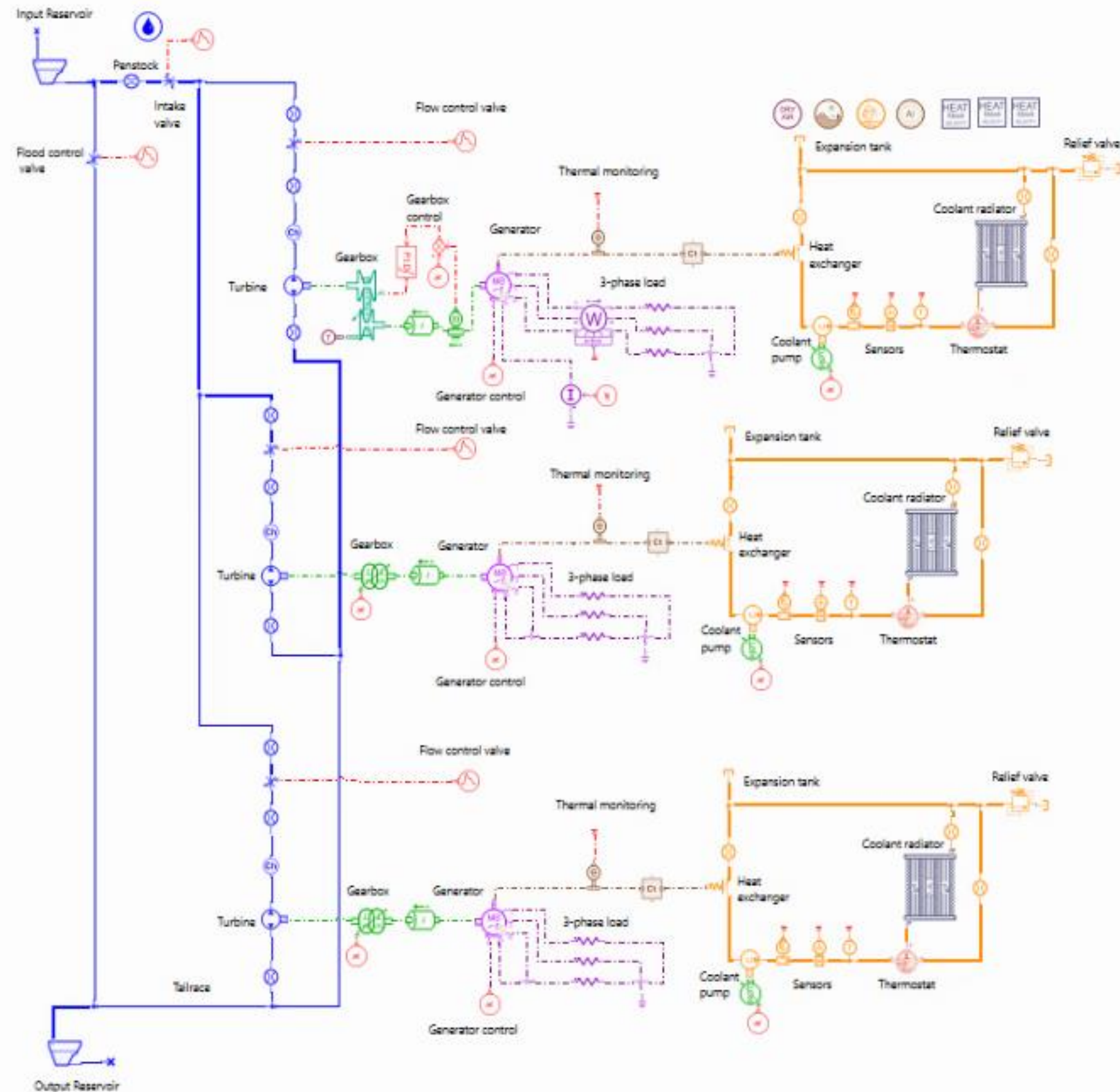


European Union
Project N° 101



A **Digital Twin (DT)** of physical hydropower plant (PPCs- Ilarionas HPP) was developed. It includes all major HPP systems (Signal and controls, Hydraulics, Pneumatics, Mechanics, Electrics, Thermal etc.).





The specific **Digital Twin (DT)** will be based on the Ilarionas HPP which is capable of supplying the essential data required:

- High level of digitalization and existing digital infrastructure
- Most input signals needed are already captured on-site
- Availability of historical data in a digital format
- Availability of schematics for mechanical, electrical, hydraulic and control systems
- Newer HPP with modern electromechanical systems

Key modelling achievements

- Developed and calibrated **custom dynamic models from scratch** for the 3 Greek HPPs (PPC), including **pumped-storage operation**.
- Integrated the 3 models into CERN's **INTEMA.grid** simulator to represent their coordinated operation as a **single cluster**.
- Assessed the cluster's operation through long-term scheduling and short-term disturbance simulations.

Key results

- **Scheduled operation:** The models successfully reproduced the predefined unit scheduling and active-power exchanges under a real **seven-day demand profile**.
- **Frequency response test:** Under a 20% load disturbance, the addition of the **3 HPP cluster** provided a more stable response, improving the frequency nadir from **49.415** to **49.603 Hz**, compared with the system **without HPP support**.

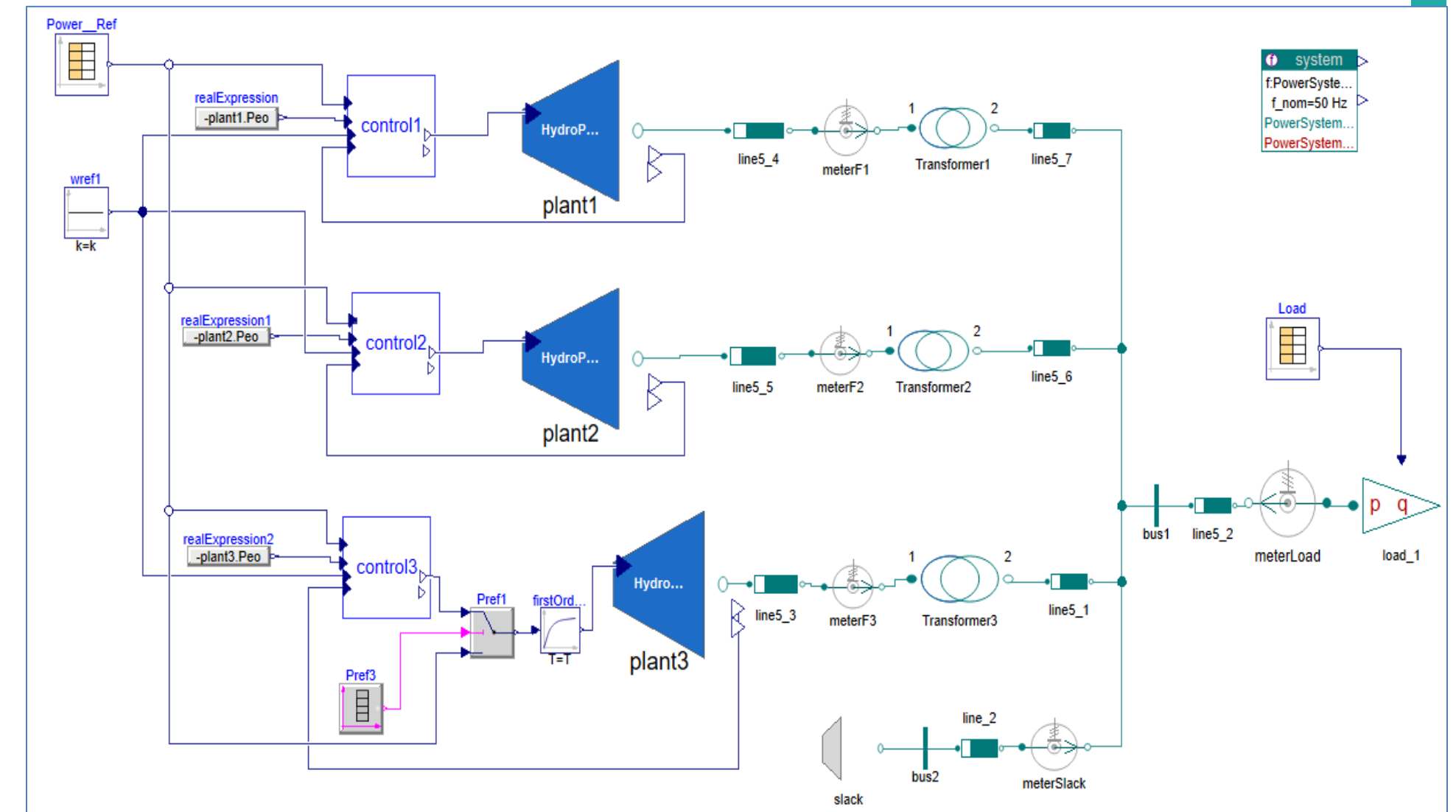


Figure: Graphical representation of the Greek HPPs' system model

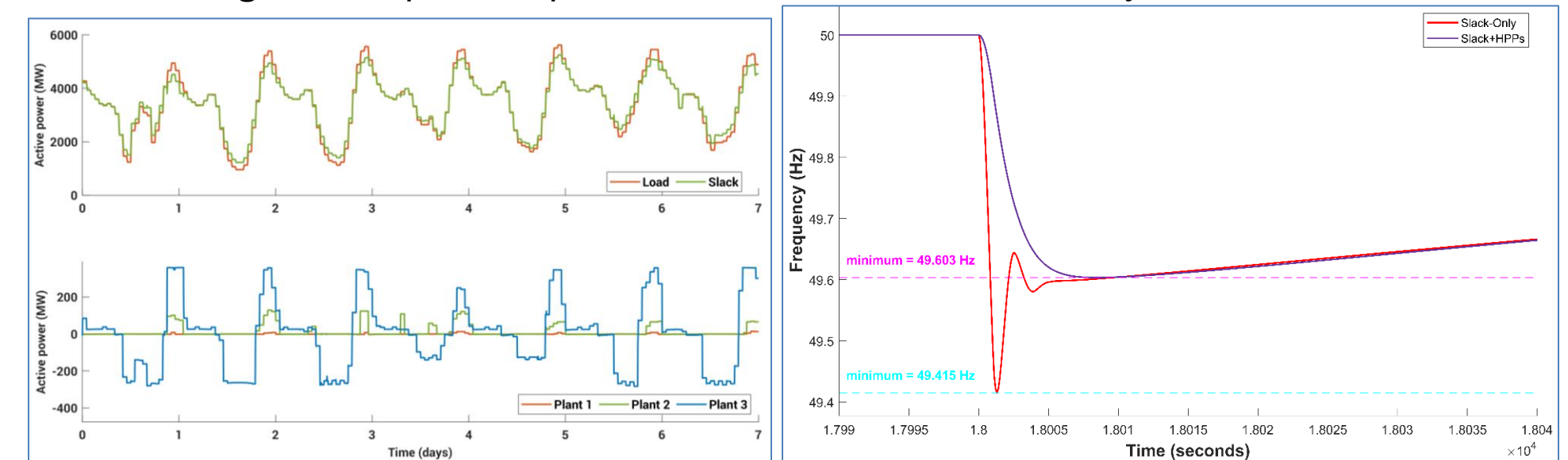


Figure: Simulation results including active power flow (left) and frequency response (right)

Use Case 2 – A2A- *Italy*

Inflow forecasts at flexible lead-times according to meteorological evolution in the upstream catchment.

- Collection of historical data
- Installation of flow meter sensors
- Weather and water flow predictive AI-based modelling and forecasting

Ampezzo and Somplago HPPs



Capacity: 235 MW
Turbines: 3x Pelton
(Ampezzo), 3x Francis
(Somplago)
Storage HPPs



LOCATIONS:



Novarza Dam
 Udine, Italy

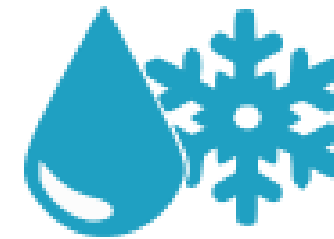
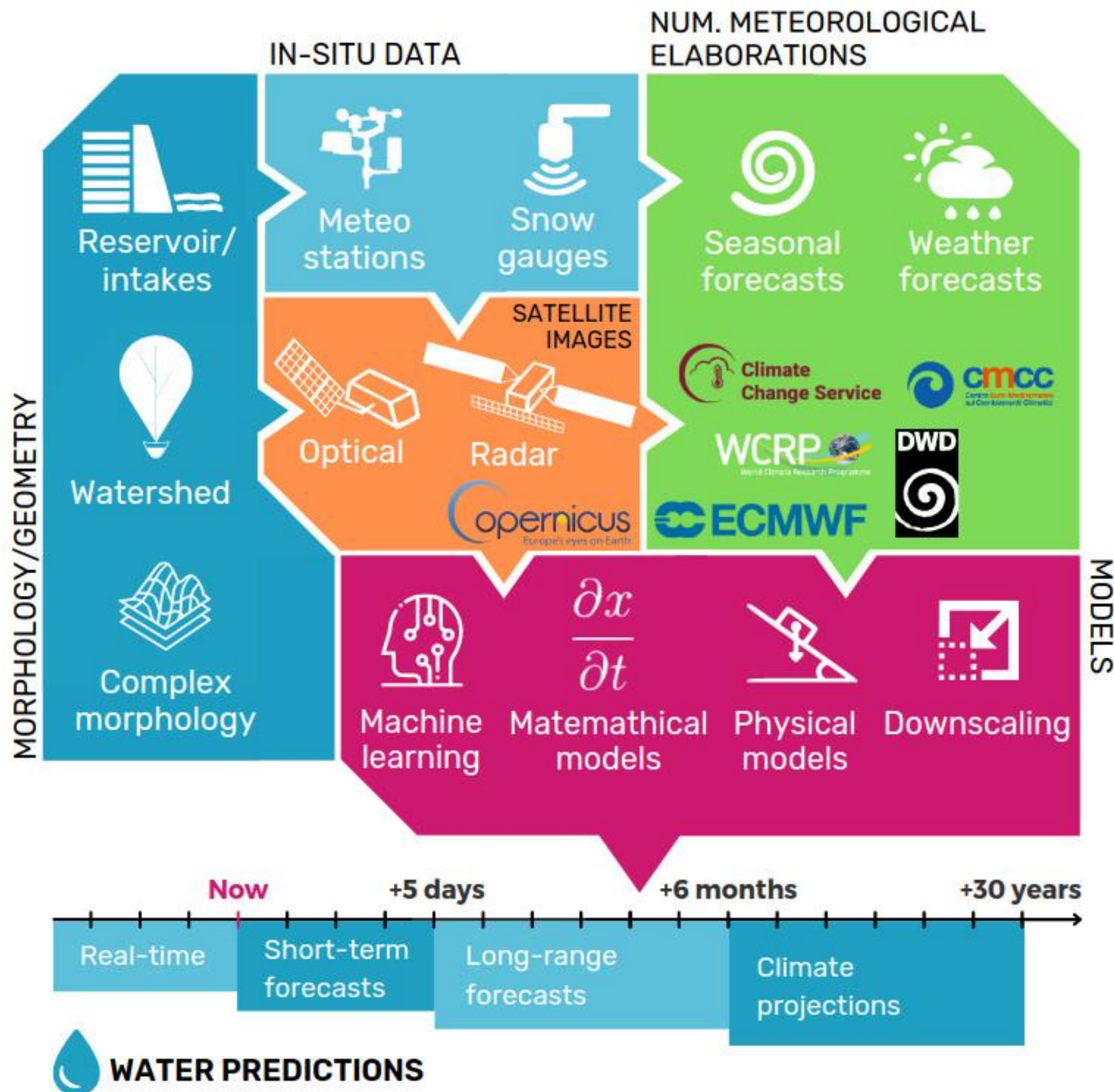


Sauris Lake
 Udine, Italy



Verzegnis Lake
 Udine, Italy

Hydrological modelling and water inflow forecasting



Digitize all the components of the water cycle of the catchment (Sauris and Verzegnis lake)



Provide accurate forecasts of water inflow in points of interest



Short-term forecasts (up to +72 hours)

Long-term forecasts (up to +6 months)

Use Case 3 - Serbia

Development and implementation of a digital sensor-based real-time water quality monitoring system (with early warning)

- Collection of historical data
- Development of sensors for biodiversity and environmental monitoring

Međuvršje HPP



Capacity: ~10 MW
Turbines: 1 x Francis, 2 Kaplan

Installation of sensors for measurement of:

- Turbidity
- Ammonia
- Electroconductivity
- Dissolved oxygen
- Algae concentration



Electroconductivity



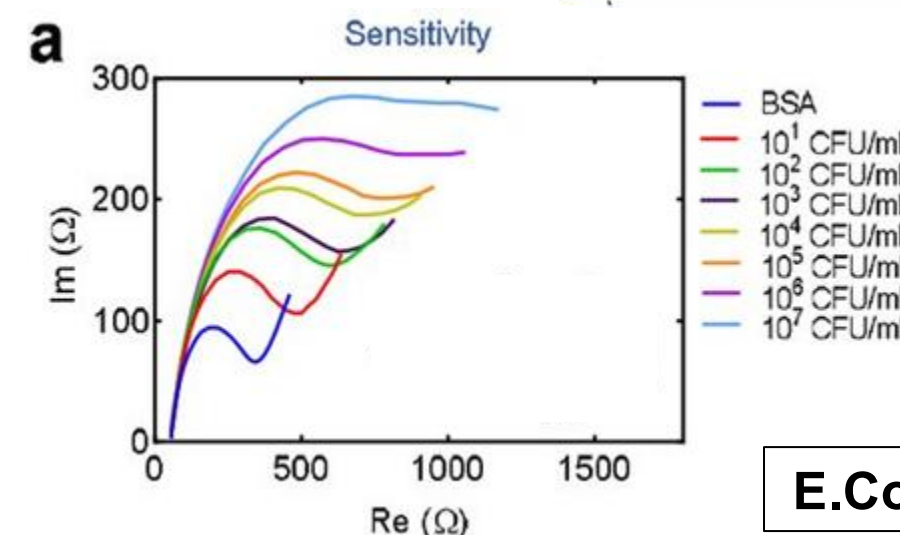
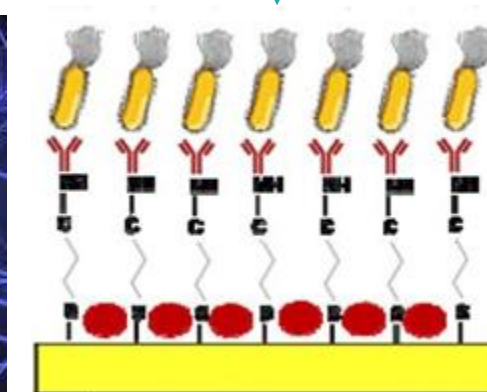
Turbidity



Ammonia detection



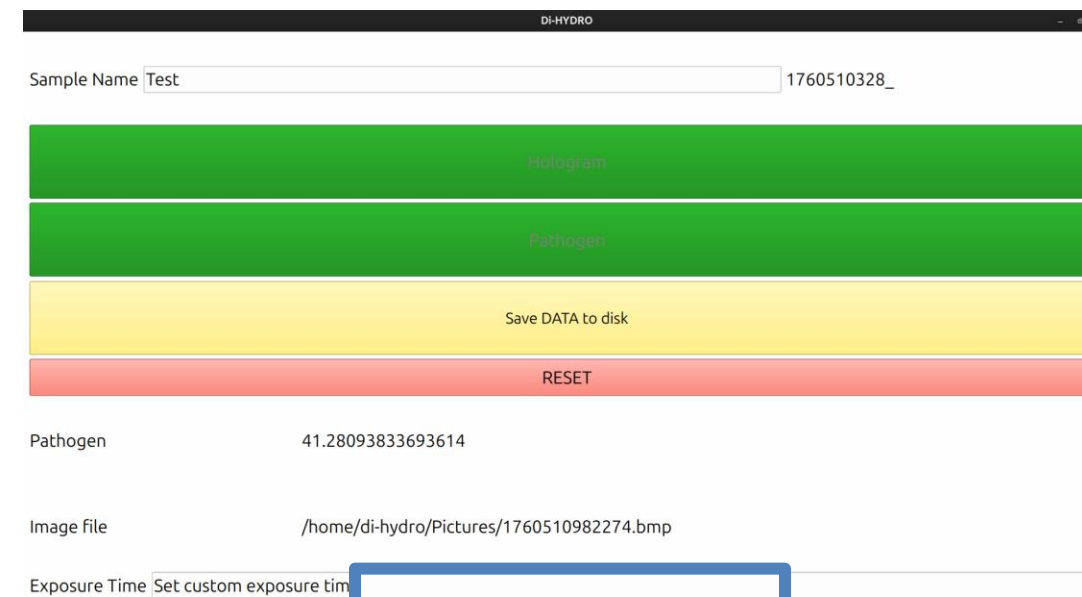
Algae concentration



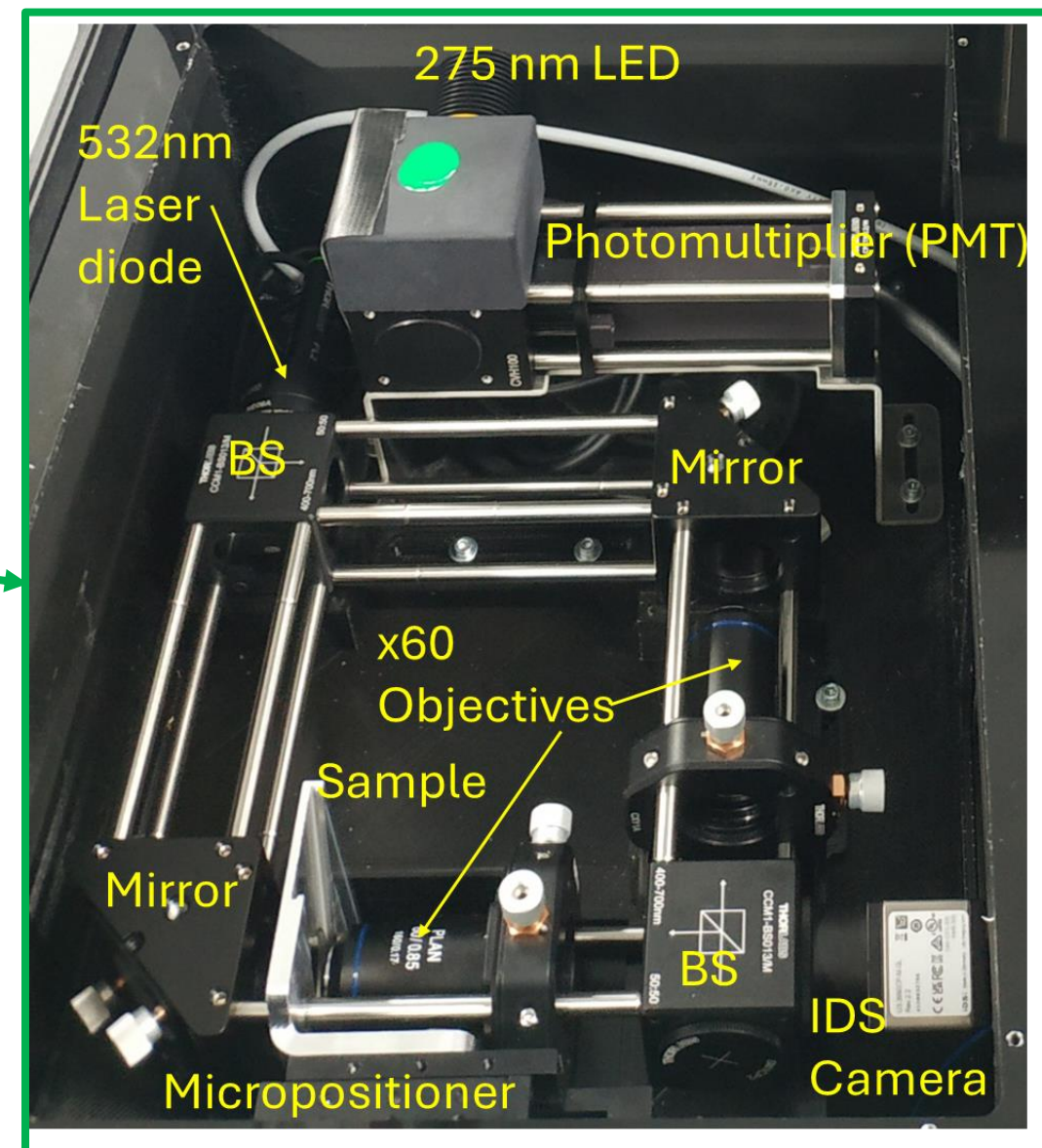
E.Coli detection



**DHM & TLF
integrated
sensors.**



Control software



DHM & TLF for biodiversity monitoring

- **Portable suitcase configuration** with DHM & TLF sensors integrated (custom design of mechanics and electronics).
- **Custom GUI** displayed on touchscreen for sensor control and data display.
- Handled to EPS personnel (training included) to periodically perform measurements in their water reservoir.

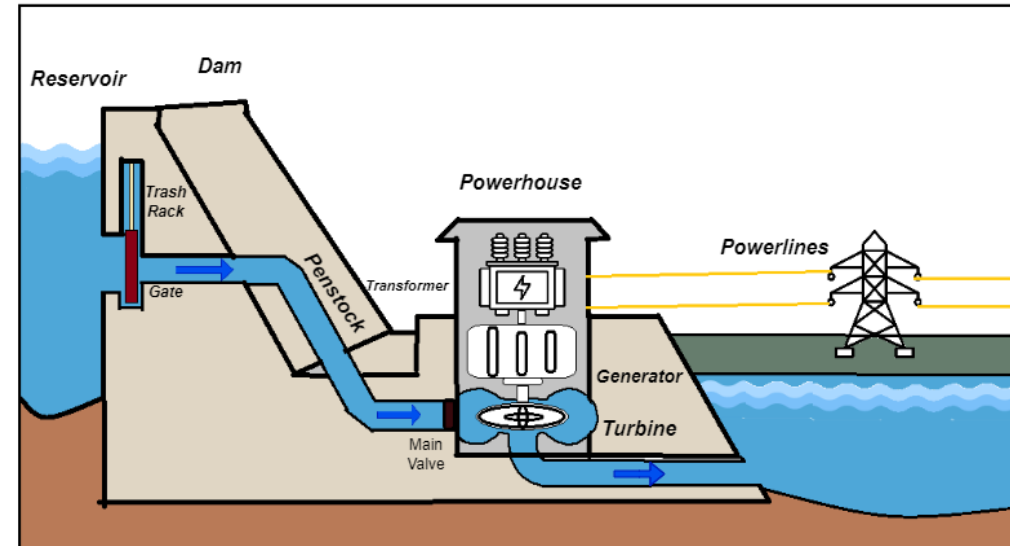


*Filamentous Blue-Green algae
(Anabaenas)*



Cyanobacteria

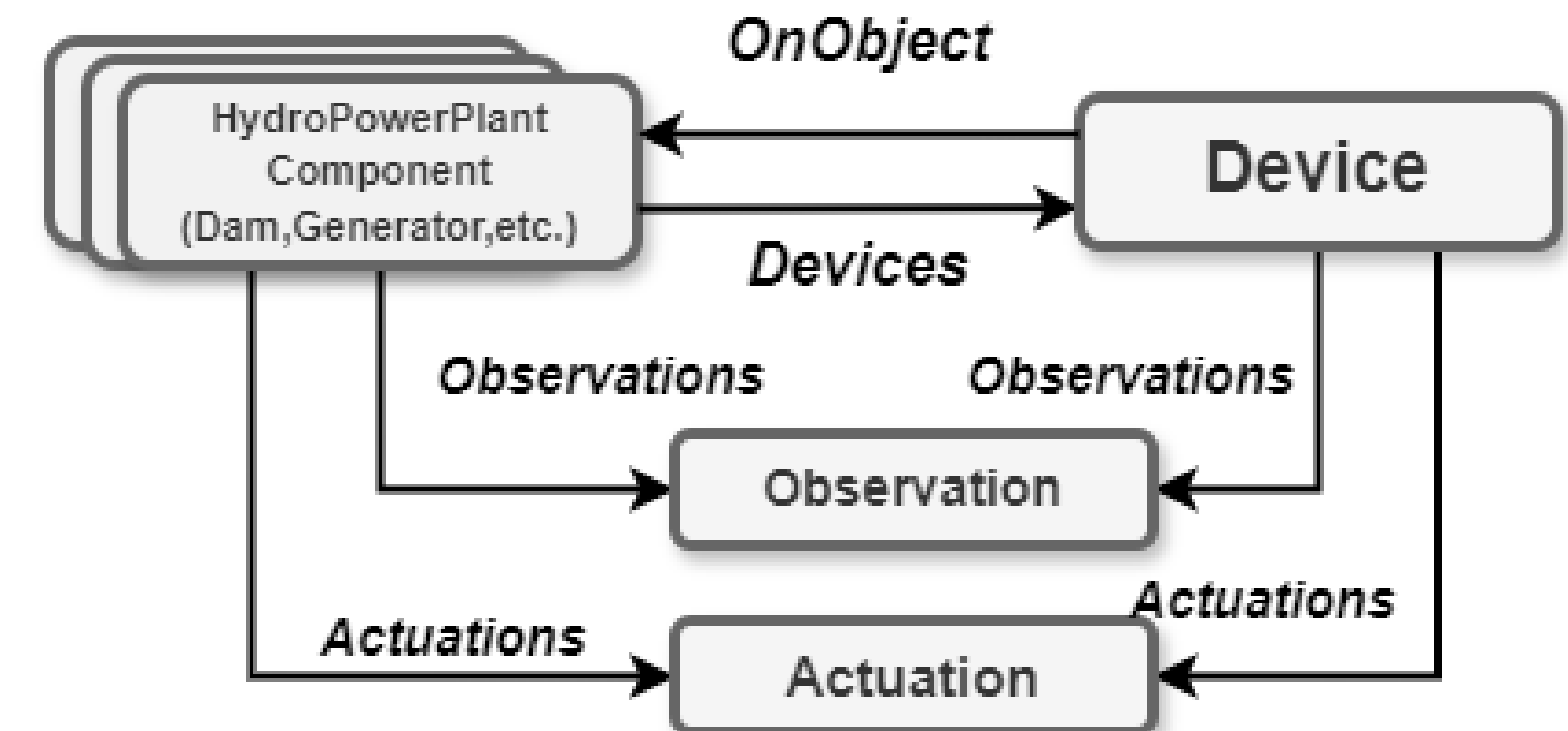
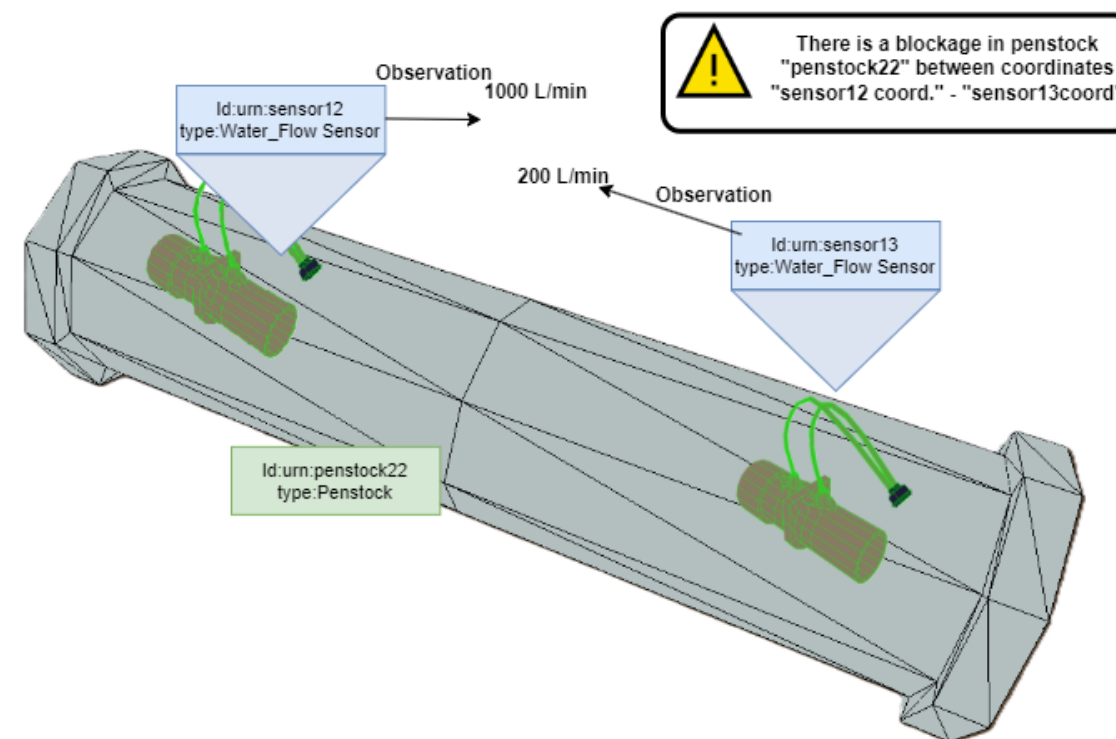
Static Data



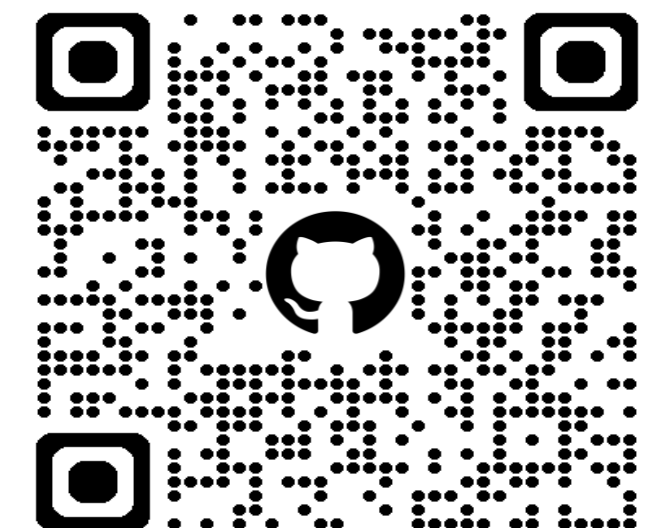
Query: Get Real-Time and Historical Water Flow Rate Measurements for a Specific Penstock. Filtering by Date Range:

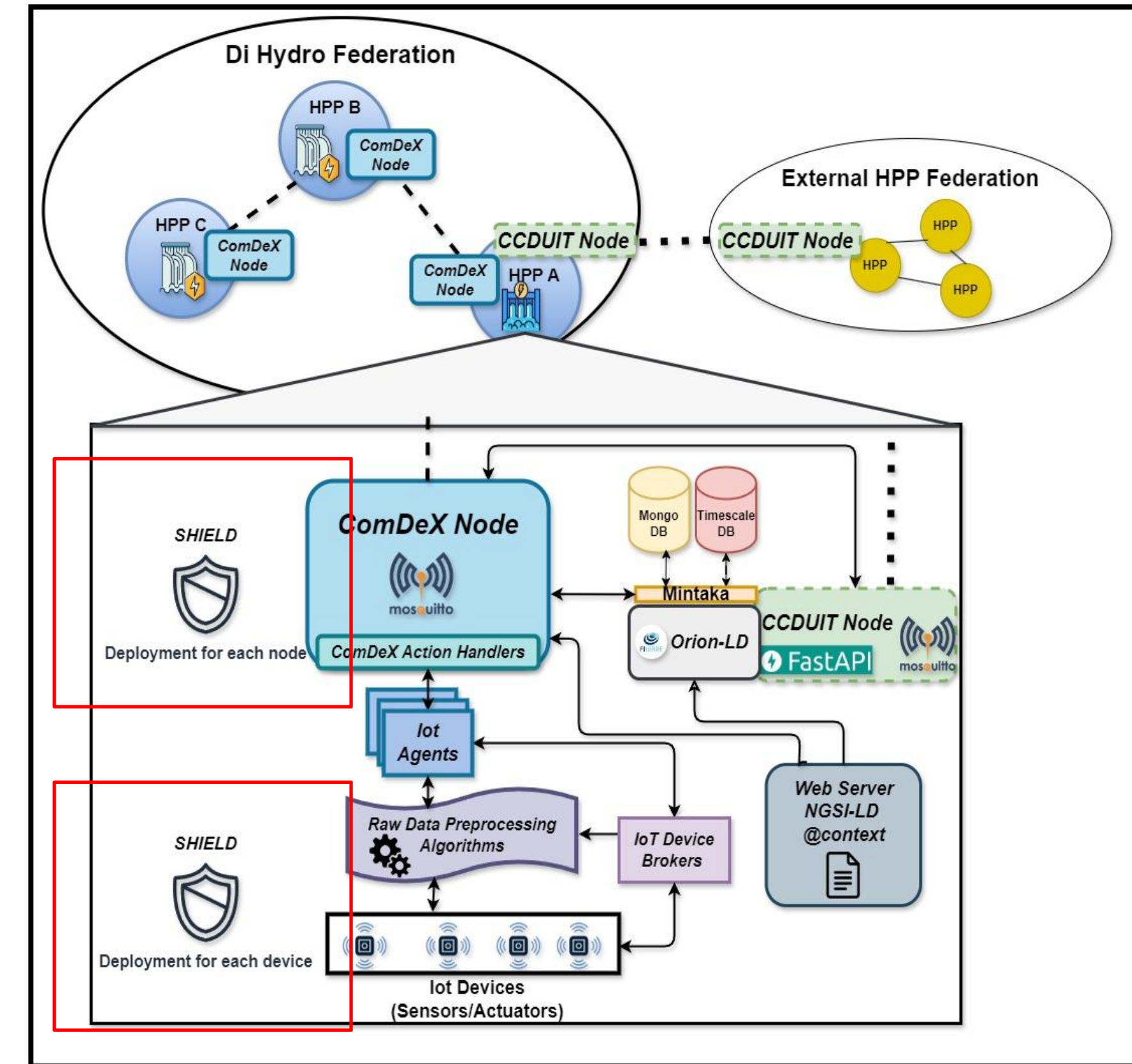
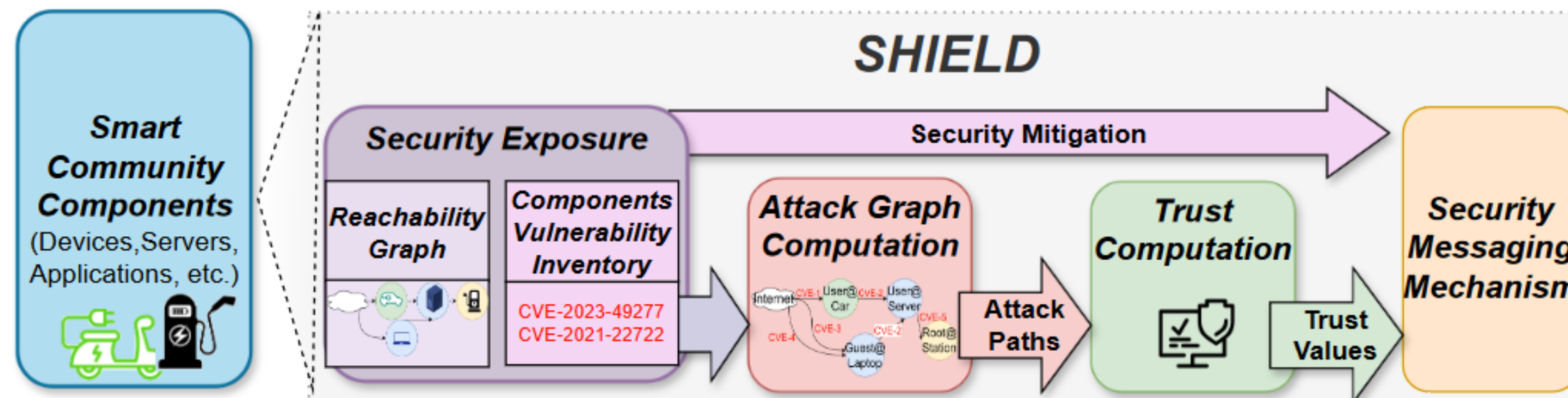
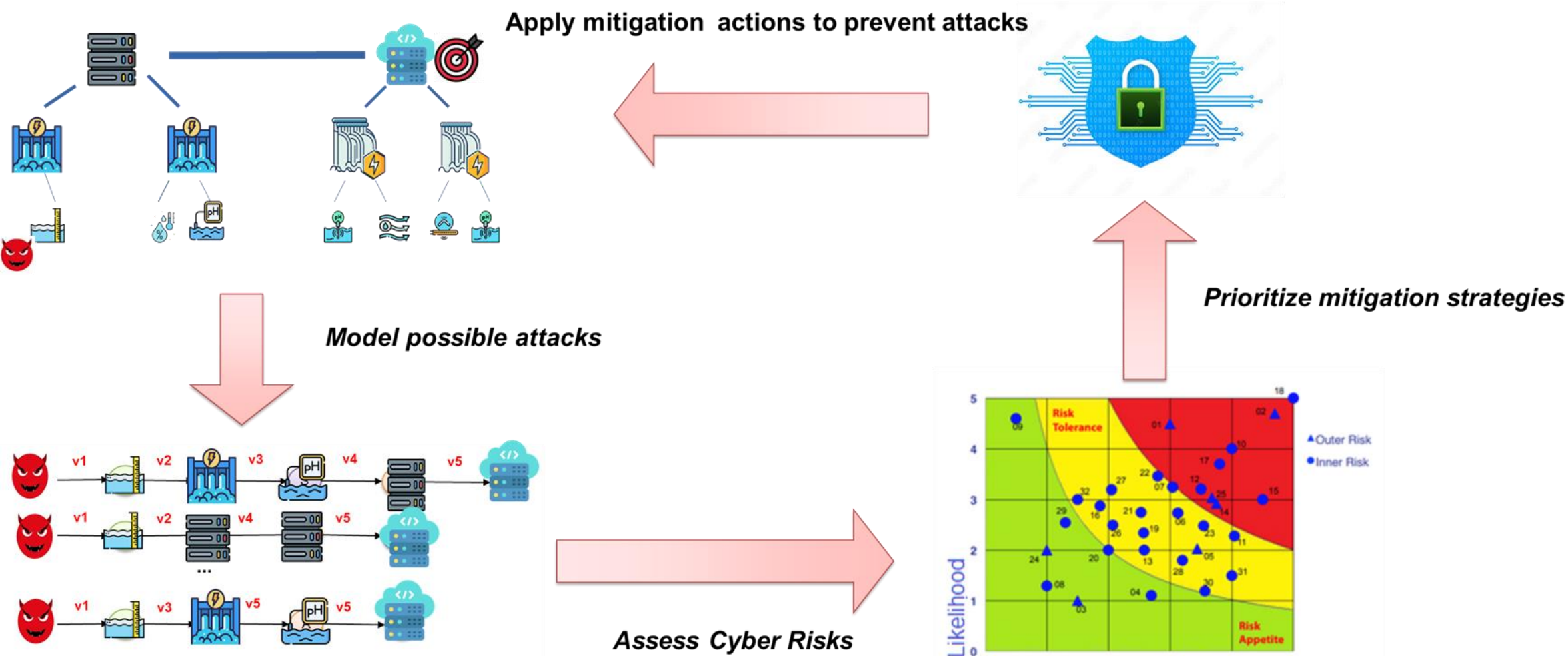
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curl -X GET 'serveraddr/ngsi-ld/v1/entities/urn:ngsi-ld:Penstock:001?attrs=observations'
curl -X GET 'serveraddr/ngsi-ld/v1/entities/?type=Observation&id=urn:ngsi-ld:Observation:WaterFlow:001,urn:ngsi-ld:Observation:WaterFlow:002&attrs=measurement.waterFlowRate&options=temporalValues&timerel=between&time=2024-07-01T00:00:00Z&endTime=2024-07-31T23:59:59Z'
```

Dynamic Data

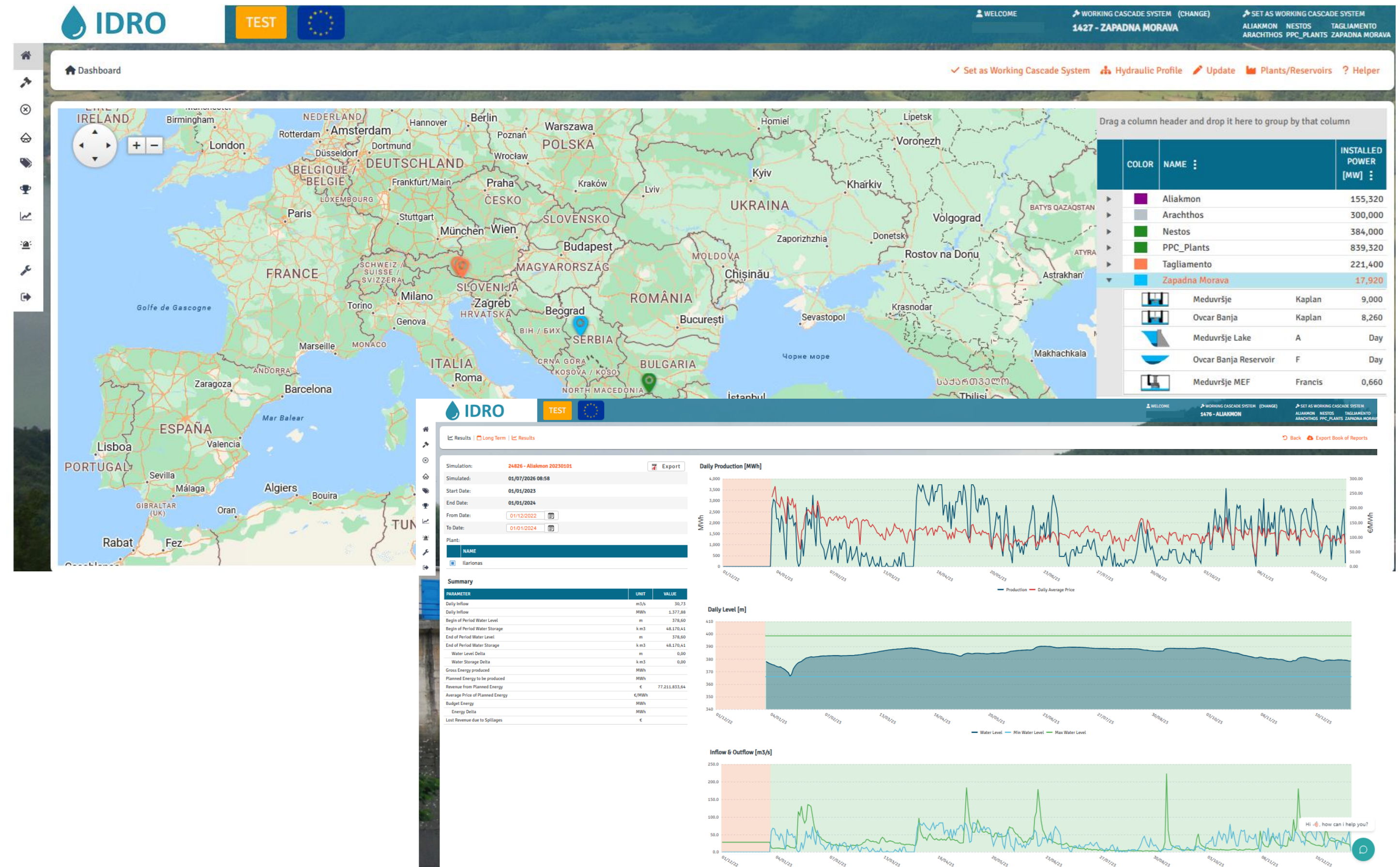


Available as Open Source!



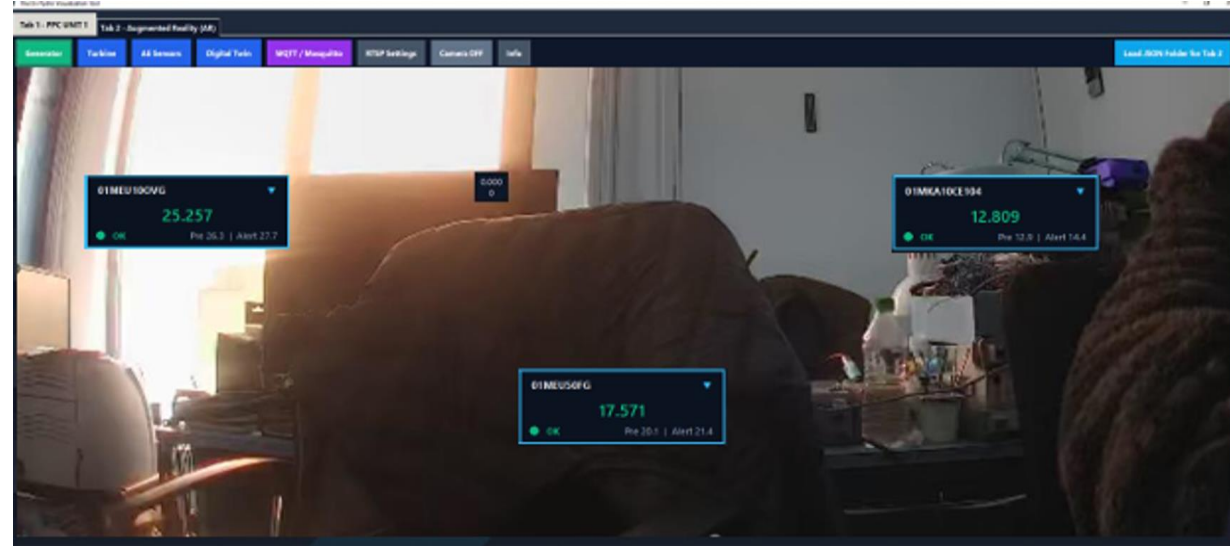


- Segregation of data according to the belonging cascade system
- Optimization input data coming from the DT layer
- Scenario-based optimizations to address the pilots' need:
 - Assess the best maintenance program
 - Make more robust decisions exploiting different scenarios of inflows forecasts
- Visualization of results according to the pilots' required KPIs and optimization objectives





HPP AUGMENTED REALITY SURVEILLANCE



HPP LOCAL SURVEILLANCE HW & SW SOLUTION



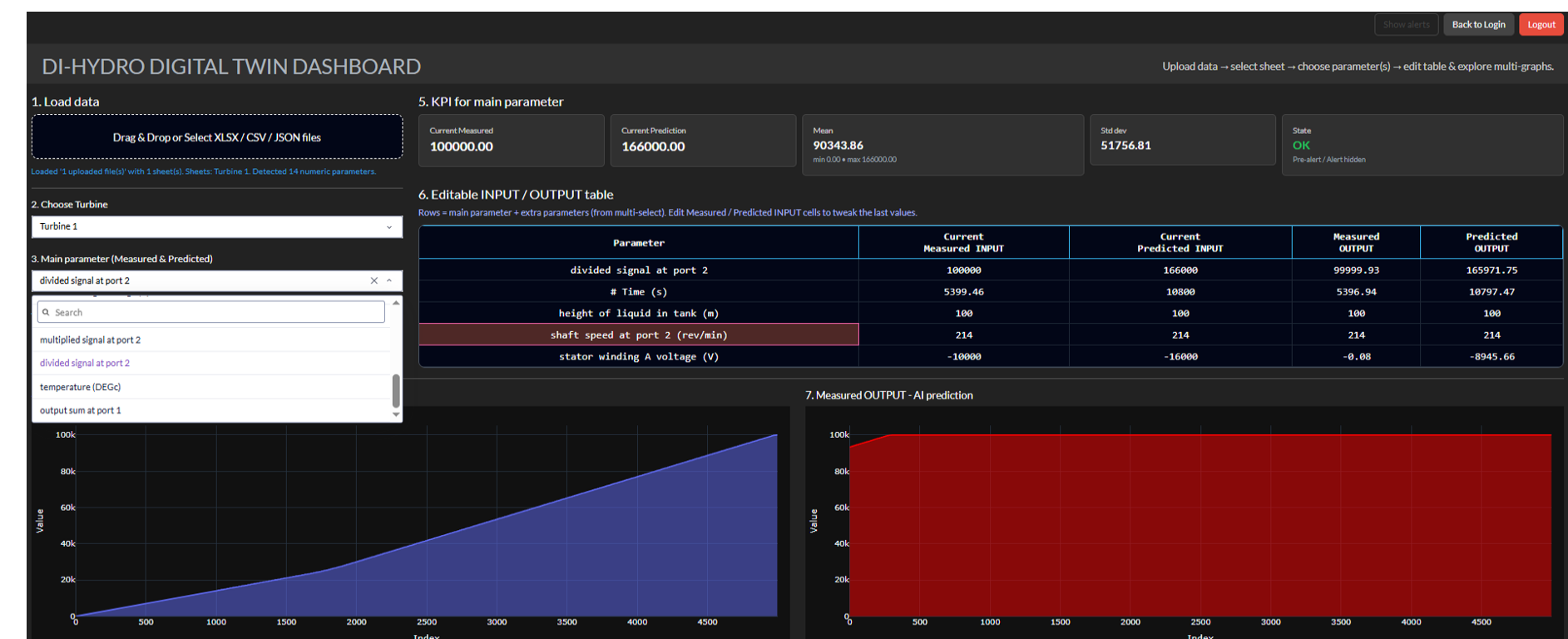
- ✓ Scalable
- ✓ Built with Python
- ✓ Data Server Interrogation
- ✓ Forecast Visualization
- ✓ Digital Twin
- ✓ Database Compatible
(Azure, SQL, .csv file)
- ✓ Flashing Warnings
- ✓ Big Size Screens
- ✓ Data Auto Refresh

OPERATOR VISUALIZATION TOOL EXAMPLES

HPP FEDERATED DATA VISUALIZATION WINDOW



DIGITAL TWIN FEDERATED DATA VISUALIZATION WINDOW



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Check out the
Di-Hydro Innovation Handbook,
featuring the main results from
the project!



Digital maintenance for sustainable and flexible
operation of HYDROpower plant

Thank you.

Dr. Alkiviadis Tromaras

Research Associate

CERTH

atromaras@certh.gr



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