ETIP Hydropower and new hydropower Horizon projects

D-HYDROFLEX Project Overview

Funded by the European Union

D-HYDROFLEX at a glance

Title
Digital solutions for improving the sustainability performance and flexibility potential of hydropower assets

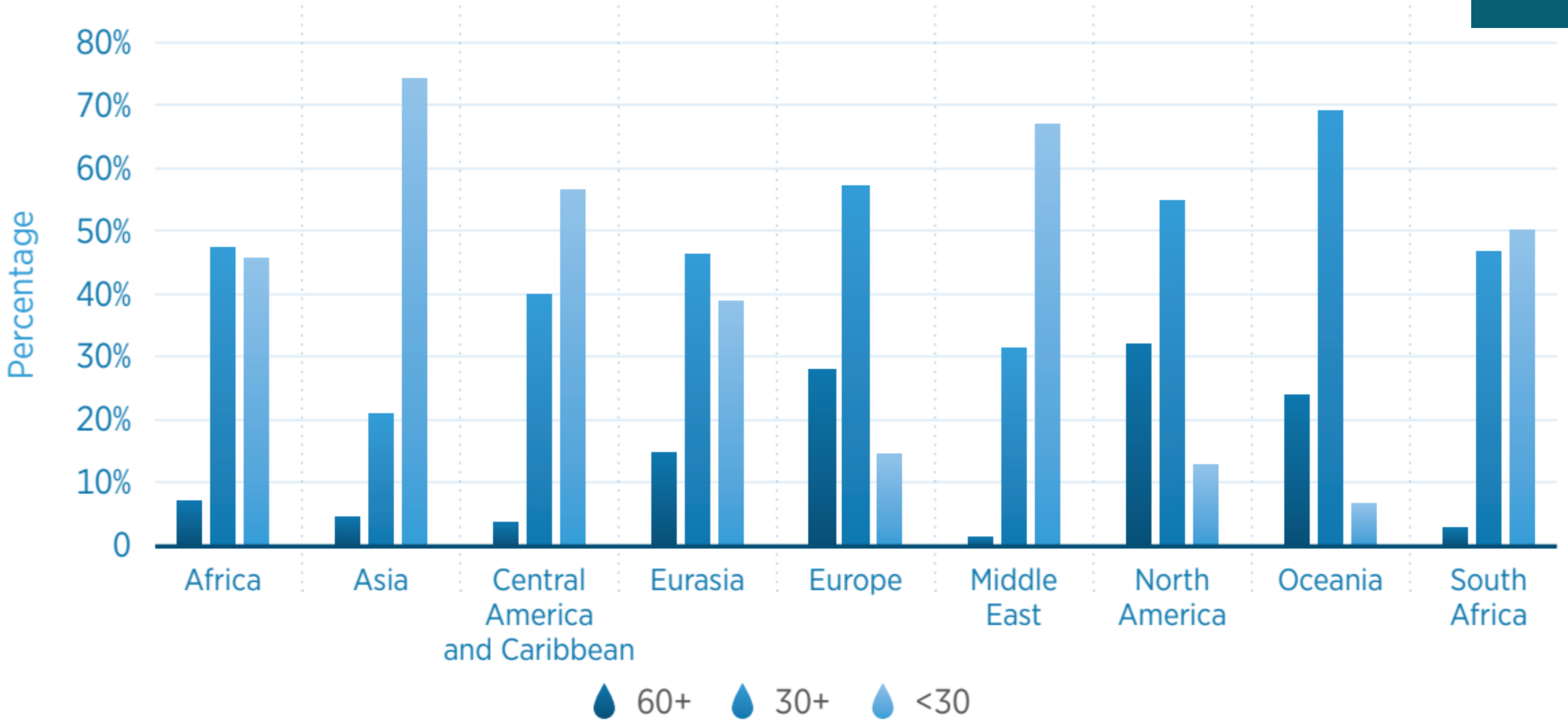
4.04 M

18 partners

3 years

September 2023

Main drivers of D-HYDROFLEX project



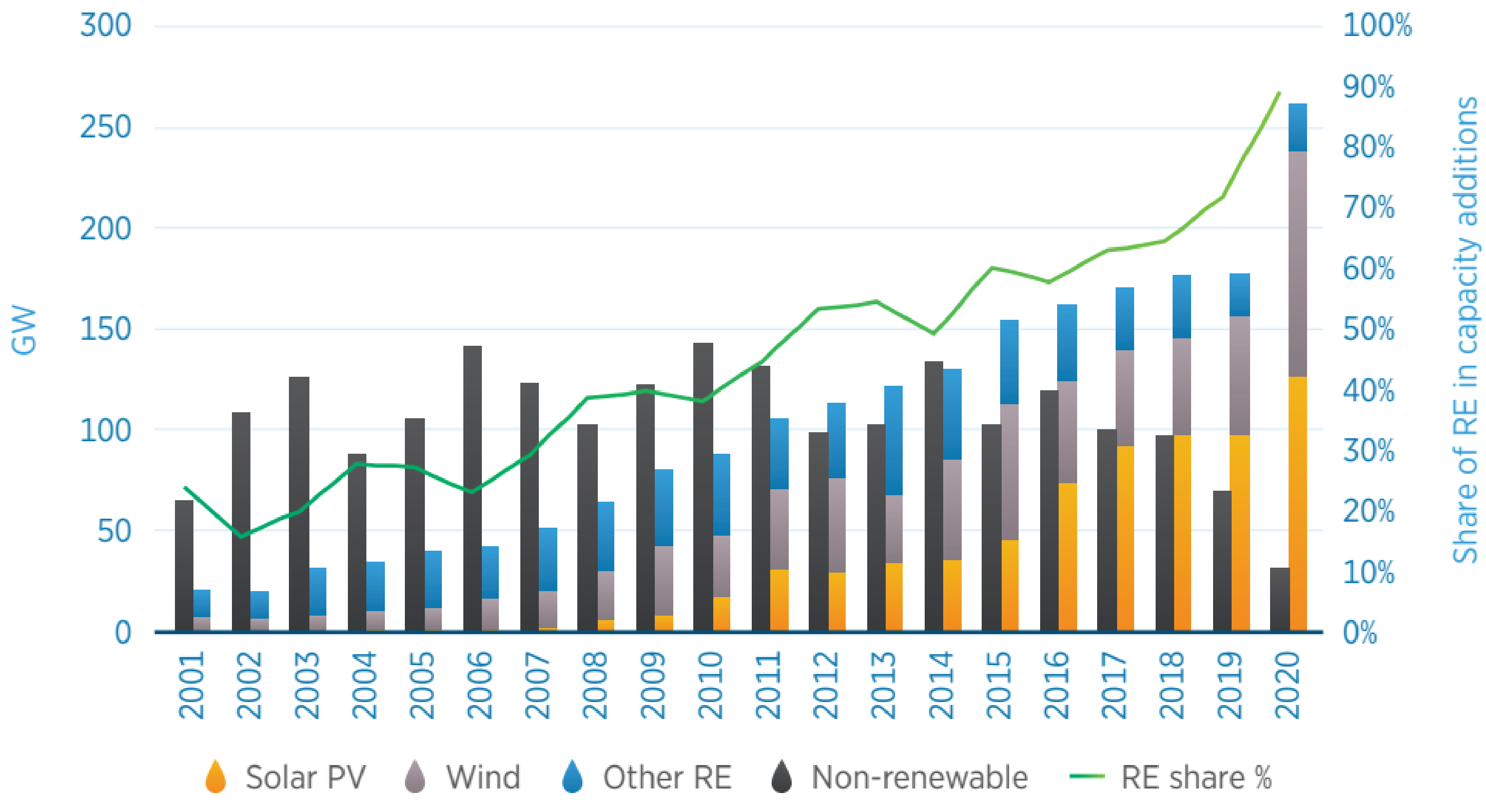
Need for investments and modernizing ageing plants

IRENA estimated that if the climate goals are to be achieved by 2050, the necessary investments in hydropower are:

- more than **three times the investment seen in 2017**, and
- more than **five times the investment in 2018**.

Main drivers of D-HYDROFLEX project

Comparison of renewable and non-renewable net capacity additions, 2001-2020



Increased flexibility needs of system operators

- System operators increasingly need to rely on dispatchable electricity sources like hydropower for frequency control, energy storage and peak load supply.
- For hydropower to have a relevant role in future energy systems, beyond baseload generation, it will have to **contribute to the grid with both capacity** (short-term flexibility) **and energy** (medium- and long-term flexibility).

Main drivers of D-HYDROFLEX project

Typical installed costs of hydropower projects

	Installed costs (USD/kW)	Operations and maintenance costs (%/year of installed costs)
Large hydro	1 050 – 7 650	2 – 2.5
Small hydro	1 300 – 8 000	1 – 4
Refurbishment/upgrade	500 – 1 000	1 – 6

More safe and cost-efficient plant operation and maintenance

- In 2013, EPRI estimated that expanding the operating range of the existing PSH plants in the US **could increase their income by 61%** on average.
- **Digitalization** opens the door for implementing predictive maintenance strategies, which could **reduce O&M costs** and **increase plant availability**.

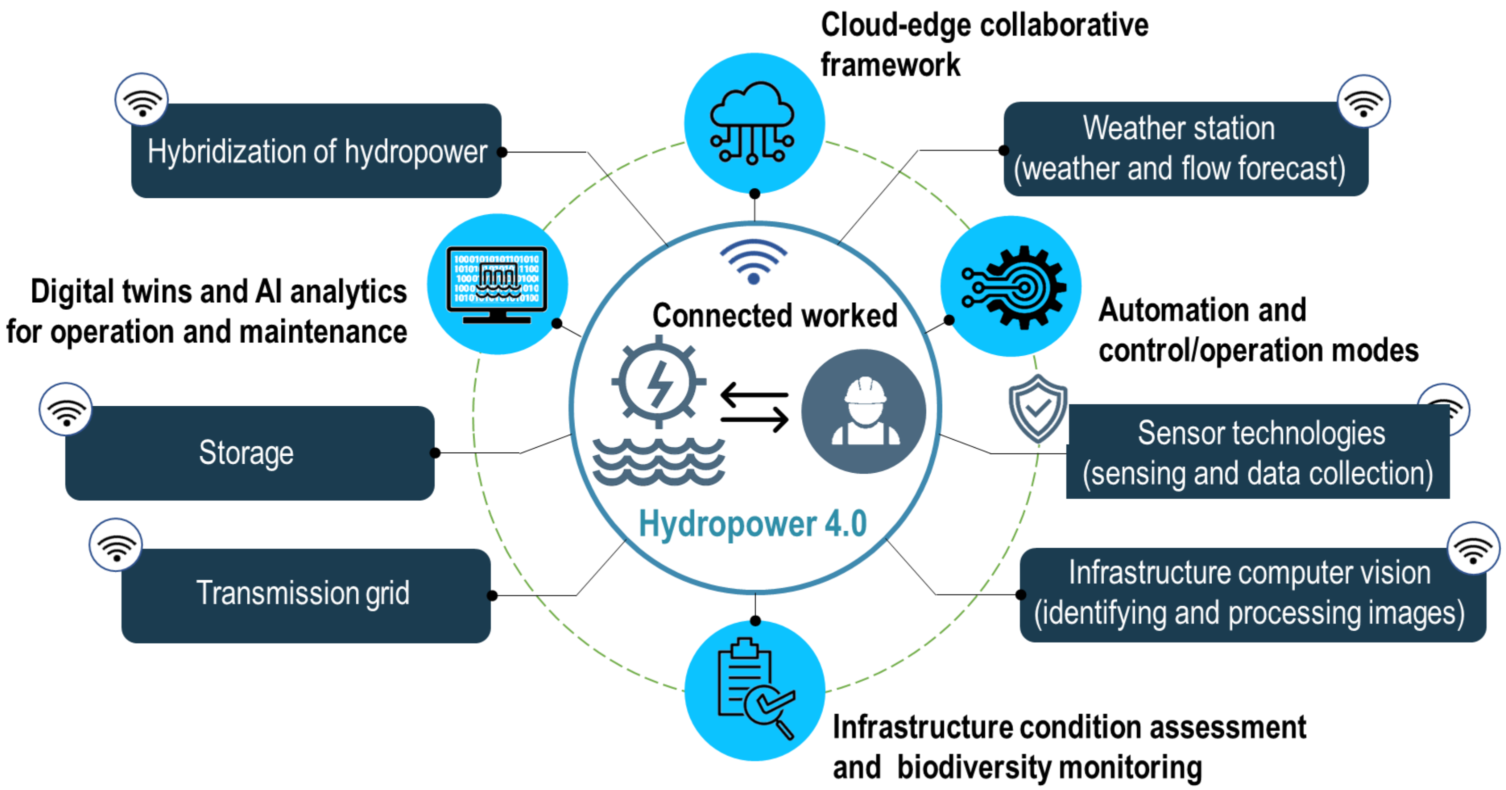
Main drivers of D-HYDROFLEX project

Topics covered by Hydropower Sustainability Standard

Need for economically viable sustainability standards

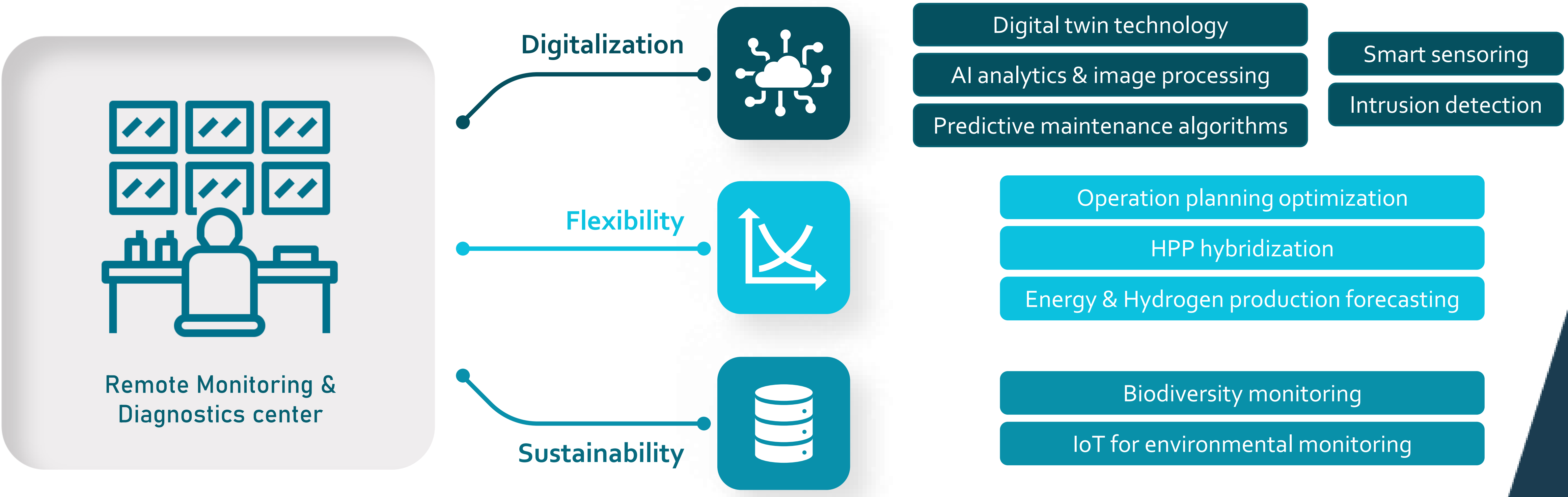
- Hydropower projects must be sustainable and resilient. This can be achieved by ensuring that adequate measures that **protect communities**, **water flows**, **water quality** and **local species** are embedded throughout the development and operation of hydropower projects.
- Hydropower technology has made considerable **progress toward sustainability** over the last couple of decades (i.e., fish-friendly turbines etc).
- However, **additional research and best practices are needed** to understand and address certain phenomena.

D-HYDROFLEX Vision



- Estimations indicate that digitalisation of the world's hydropower fleet **could increase annual production by 42 TWh**, equivalent to roughly 1% of annual production.
- Digitalization enables operators to collect more data and better understand the behaviour of a plant and its components under different conditions, leading to **better informed decisions** and **better management of the plant's operations**.

D-HYDROFLEX Main Pillars



D-HYDROFLEX Objectives

Design the digitalized hydropower plant of the future based on **D-HYDROFLEX Hydropower 4.0 toolkit for real-time system management and remote monitoring** that will support plant operators in participating to wholesale power markets and will increase the efficiency of the plant operation.

Develop **IoT and digital twin technologies**, as well as **AI-based techniques for data ingestion, analysis, advanced hydro power production, weather and flow forecasting**, that will increase the cost-efficiency and operational efficiency of HPPs and facilitate their optimal hybridization with other RES and hydrogen gas.

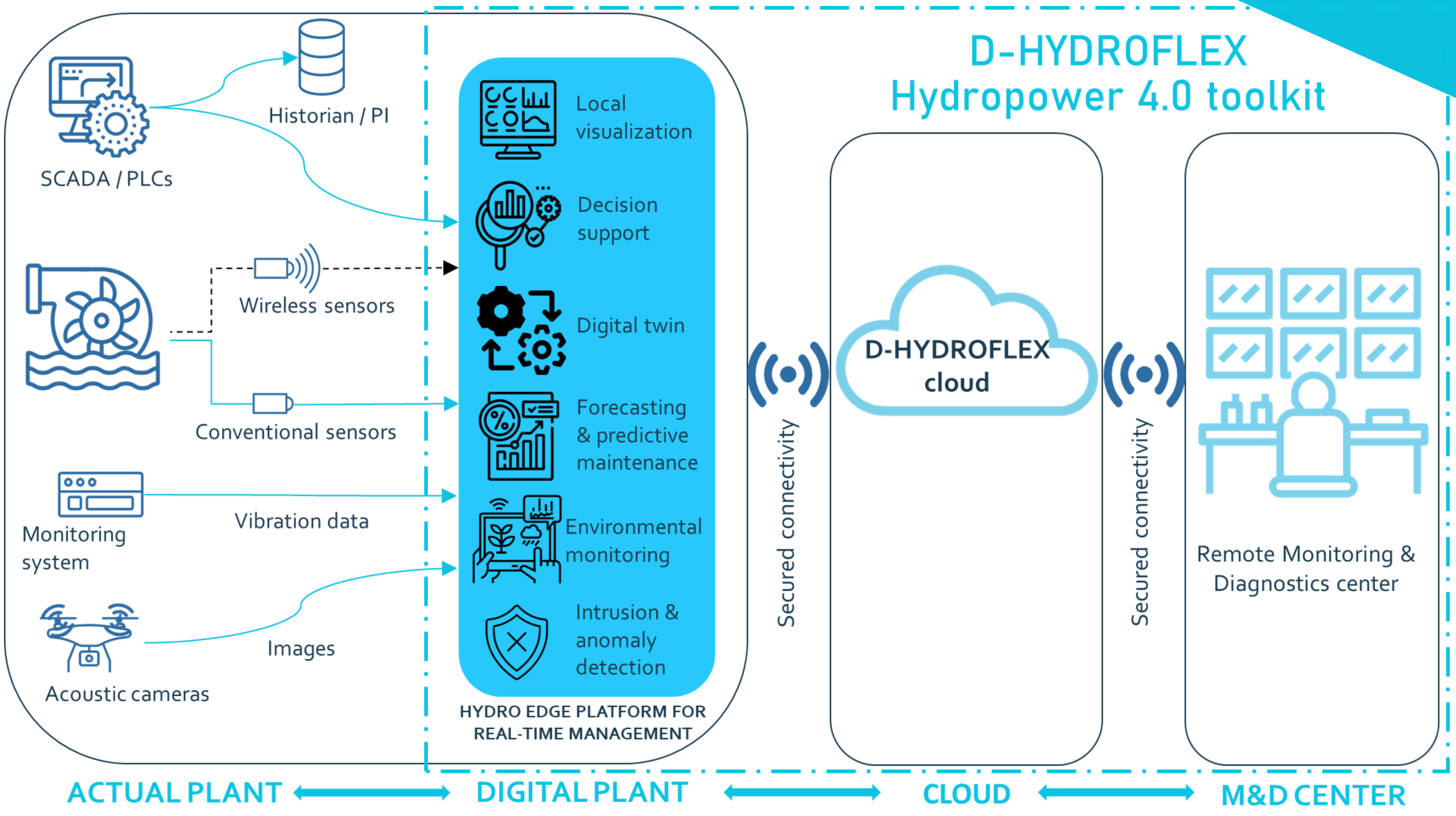
Develop **novel sensor-based modelling** and **image processing algorithms** that will reduce the HPPs' impact on fish migratory species, minimizing their environmental impact and increasing their sustainability.

Demonstrate the **applicability and value of the D-HYDROFLEX Hydropower 4.0 toolkit** through industrial and real-world applications across Europe, being evaluated in different climatic zones, operating conditions and hydro generation capacity volumes.

Introduce and test **AI-based intrusion detection and explainability techniques** for detecting and discriminating various kinds of cyberattacks and anomalies in hydro-energy operational environments.

Design a **solid set of recommendations for the existing EU regulatory and market framework** based on project results and **advance the scientific excellence** by establishing a robust communication, exploitation and impact creation strategy.

D-HYDROFLEX Concept



D-HYDROFLEX Tools

Hydro unit digital twin

This tool allows developing **digital twin of the hydro-unit** for mirroring the turbine set and visualizing the **sensor data** and **monitoring condition** in digital model to facilitate the monitoring and maintenance process.

Digital twin geometric model generation framework

This is **an AI-based framework t**hat will automatically generate **digital twin model of a dam**. Tool development will include capturing spatial and visual data from the dam on-site, as well as importing, registering, and integrating data.

Dam digital twin

This tool defines and implements methods and solutions to **integrate geometric, non-geometric and management information into the asset management platform**, including geometrics and semantics of dam components and the relationships among them.

D-HYDROFLEX Tools

Forecasting tool

The tool integrates a weather forecast downscaling model using artificial intelligence, specifically Bayesian Belief Networks, to refine ECMWF weather forecasts. Coupled with a daily hydrological rainfall-runoff model, **it predicts inflow to hydroelectric power plant water intakes**. The model incorporates snow and soil moisture dynamics, producing power production predictions based on hydro power plant characteristic curves and recorded data.

Fault detection and predictive maintenance system

This system utilizes various data sources, including vibration measurements and SCADA data, to **detect abnormalities**. The system considers data such as raw acceleration, speed, displacement measures, and frequency-related data. ISO 7919-5:2005 norms are used to compare vibration levels with hydropower standards. Advanced techniques like clustering and Normal Behaviour Modelling are employed for effective analysis and fault detection, utilizing neural networks and linear approaches for model implementation.

Decision support module for hybrid HPPs

It is a **planning tool for hydro power plants featuring a hydrolyser and H2 storage**. The tool provides recommendations about H2 production planning based on forecast of the energy produced by the HPP. This kind of hybridisation can be managed using well established optimal control or model-based predictive control strategies that lead to optimal **operation planning**.

D-HYDROFLEX Tools

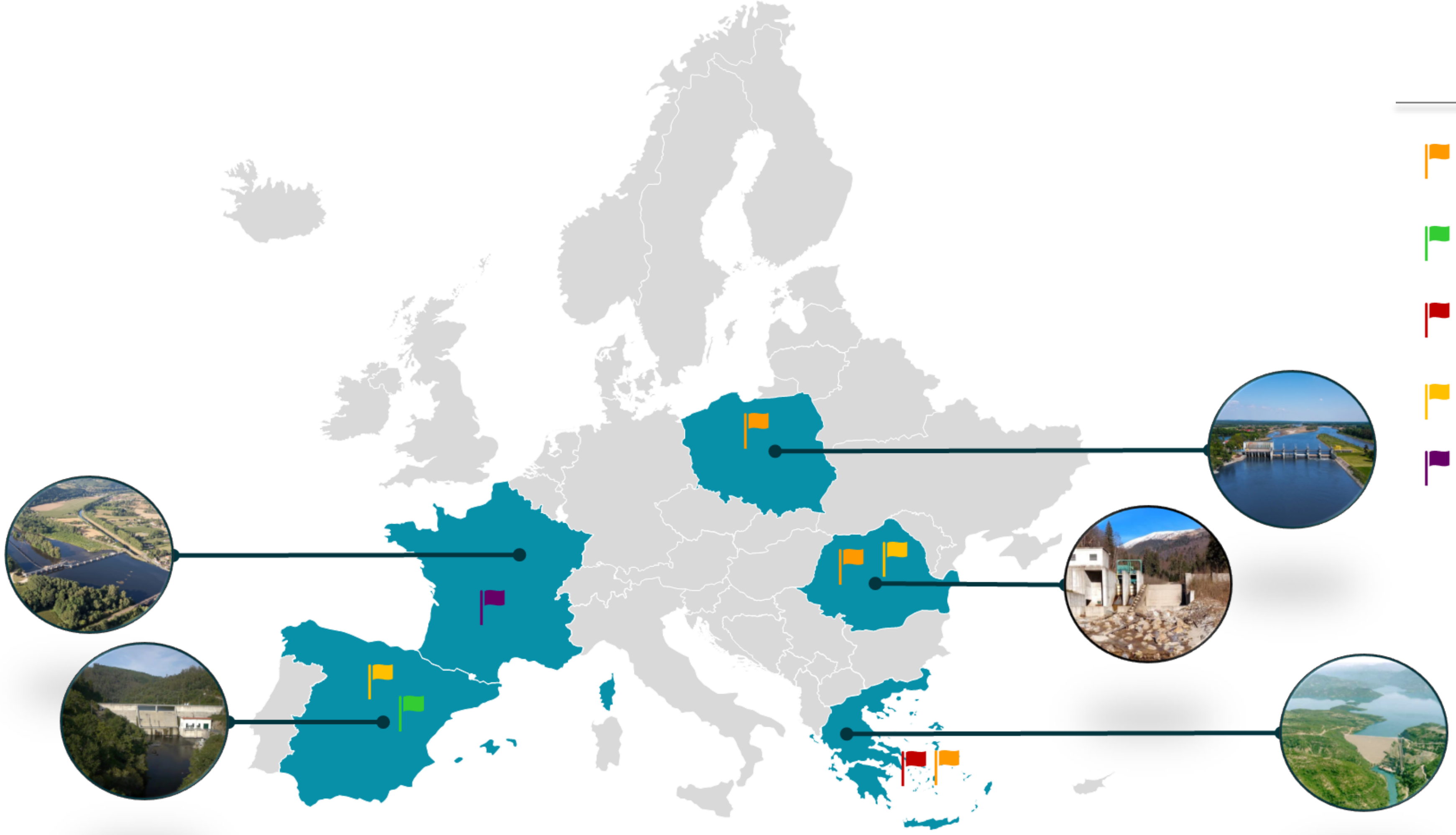
Biodiversity index tool

This tool utilizes acoustic cameras for efficient fish monitoring. An automated method, employing computer vision and image processing, will be developed **to identify fish species based on their global shape and swimming patterns**. This approach will be tested on various acoustic camera models, enhancing fish monitoring capabilities. Additionally, environmental indicators will be observed to assess the biotope condition.

F-BoX

It is a **federated cybersecurity solution** for energy systems, detecting diverse cyber threats using deep intrusion/anomaly detection models. It employs a centralised federated learning approach, combining local deep learning-based models, federated clients, and a federated server to enhance cybersecurity by orchestrating and distributing models personalized for each use case.

D-HYDROFLEX Demonstrators



Demo use case focus

- Predictive maintenance and operational efficiency maximization
- Hybridization of HPPs utilizing on-site hydrogen production in small HPPs
- Anomalies and intrusions detection in HPPs local networks
- Increasing HPPs' readiness for integration & operation into local smart grids
- Environmental impact monitoring in RoR plants

Pilot sites overview

Polish Demo

Wały Śląskie Hydroelectric Power Plant

Location	Brzeg Dolny
Capacity [MW]	10
Hydro System	4 Kaplan turbines
Type	Run-of-river

Romanian demo

Bratia Hydroelectric Power Plant

Location	Albeștii de Muscel
Capacity [MW]	1.56
Hydro System	2 Pelton turbines
Type	Run-of-river

French Demo

Mauzac Hydroelectric Power Plant

Location	Dordogne River
Capacity [MW]	13.2
Hydro System	1 Kaplan & 5 Francis turbines
Type	Run-of-river

Spanish demo

Salto de Touro Hybrid Hydroelectric Power Plant

Location	Ulla River
Capacity [MW]	12
Hydro System	2 Kaplan turbines
Type	Run-of-river

Greek Demo

Kremasta & Ilarion Hydroelectric Power Plants

	Kremasta	Ilarion
Location	Acheloos river	Aliakmon river
Capacity [MW]	437	153
Hydro system	4 Francis turbines	2 Francis turbines
Type	Earth fill	Earth fill

Thank you!

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D-HYDROFLEX project has received funding from the European Union's HORIZON Research and Innovation Action under Grant agreement No 101122357

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