XFLEX HYDRO

Increasing the flexibility of hydropower assets

AQUAWATT | 29/10/2024

Matteo Bianciotto – Senior Policy Manager

The Hydropower Extending Power System Flexibility (XFLEX HYDRO) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857832.

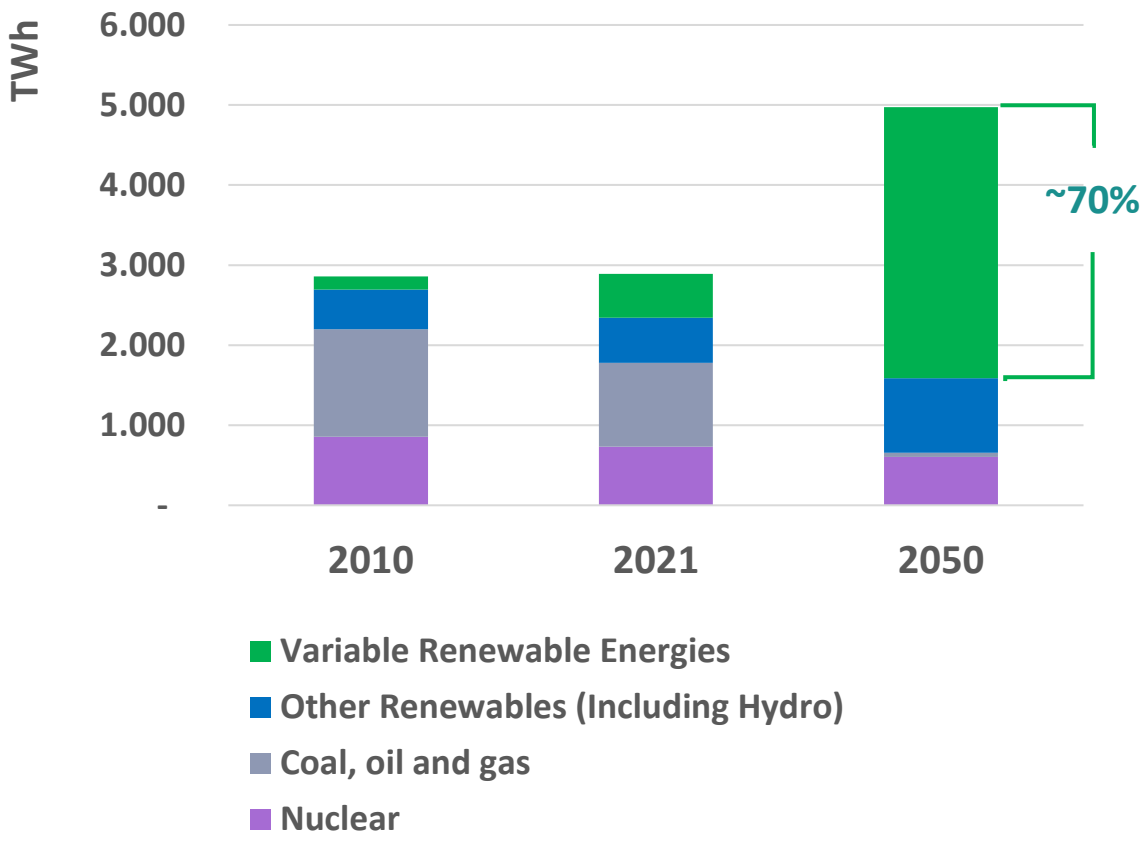
iha international hydropower association

What we will cover

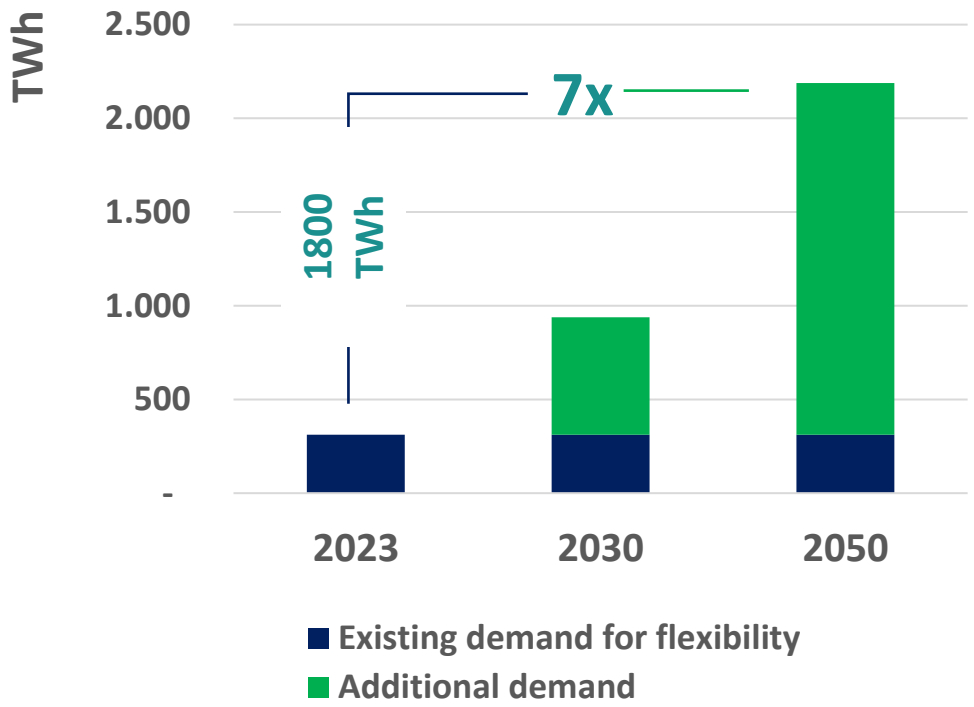
- Background
- Project introduction
- The flexibility technologies studied
- 2 examples of applications
- Policy recommendations

The call for more flexibility

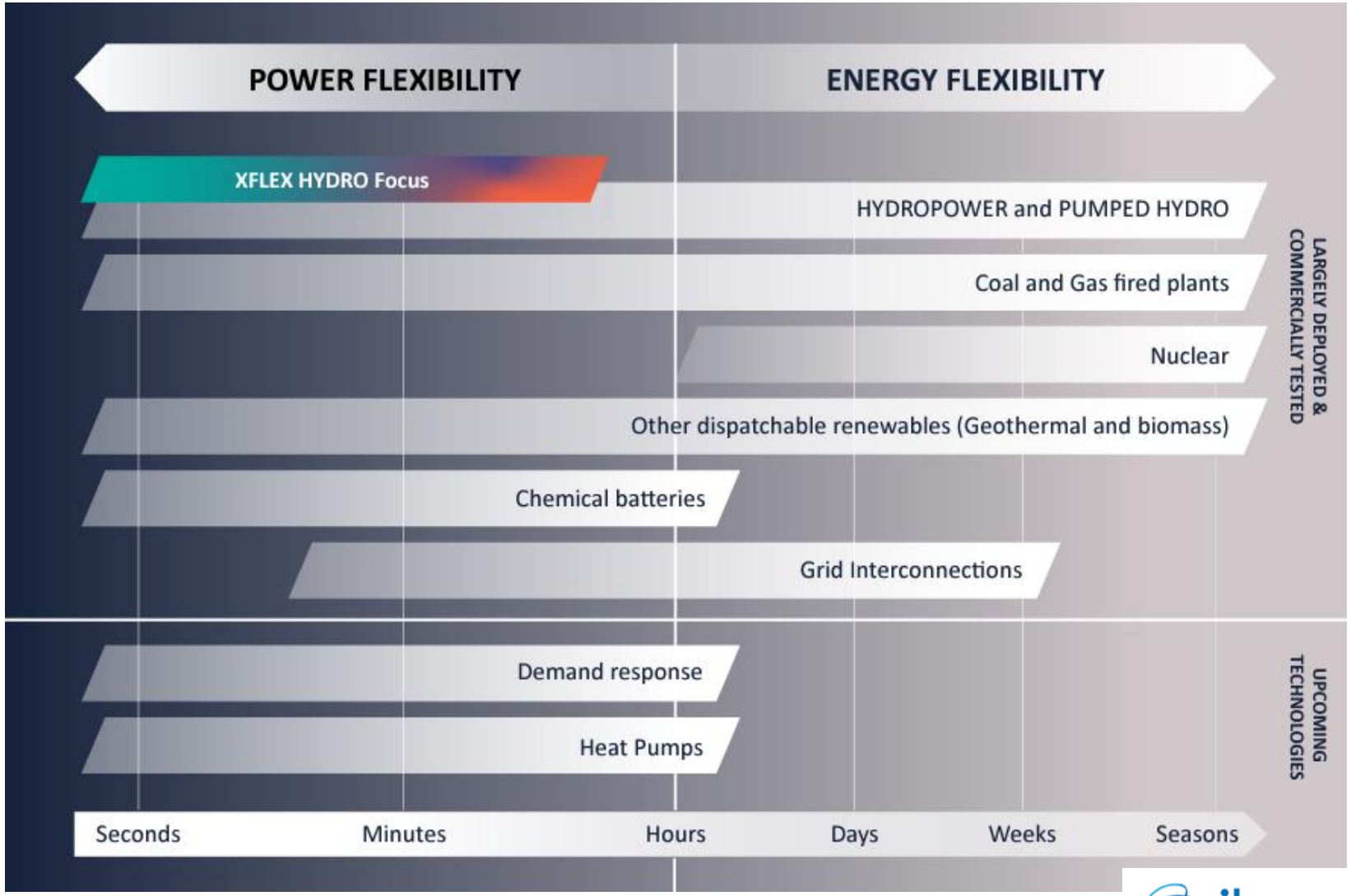
EU Electricity Mix (Announced Pledges Scenario, IEA)



EU Demand for flexibility (JRC, EU)



Available flexibility solutions



BACKGROUND

The project

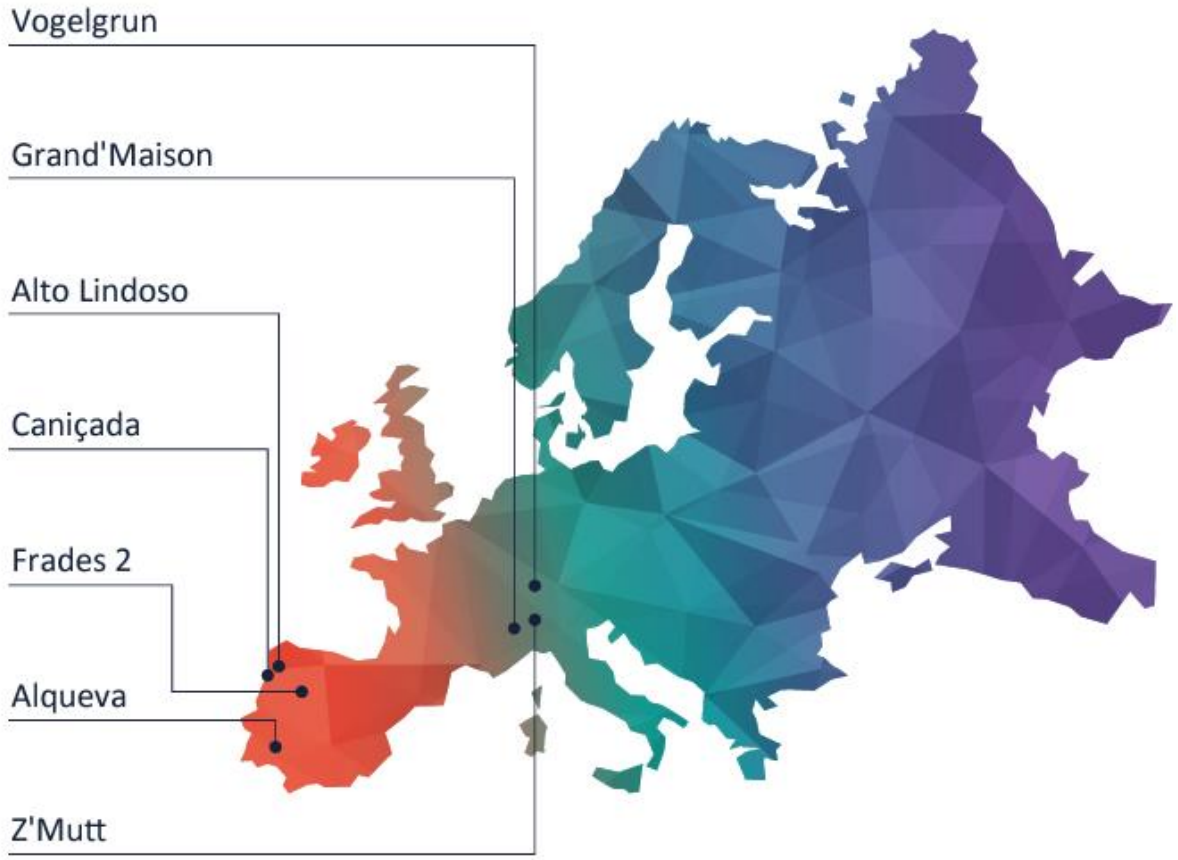
4.5-year R&I project funded by the European Union' Horizon 2020 programme.

4 innovative flexibility technologies implemented and tested.

€18m budget

7 demonstration sites in Portugal, France and Switzerland (EDF, EDP, and Alpiq).

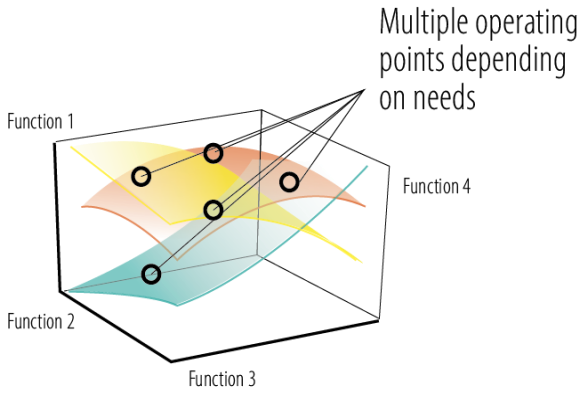
19 project partners



The Hydropower Extending Power System Flexibility (XFLEX HYDRO) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857832

The 4 flexibility technologies:

Smart power plant supervisor (SPPS)

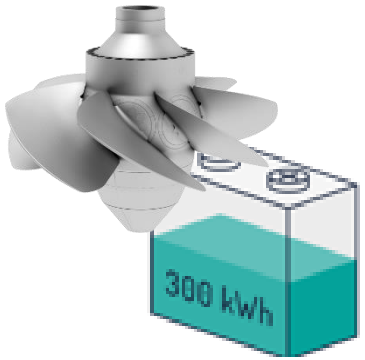


Applicability: All type of units

Benefits:

- ✓ Real time optimisation of power plant operations based on multiple factors: Efficiency, wear & tear, water consumption, unit start and stop.
- ✓ Operators can prioritise one or multiple factors;
- ✓ Optimised integration of other technologies;
- ✓ Paired with extension of operating range;

Hybridisation with battery energy storage systems (BESS)

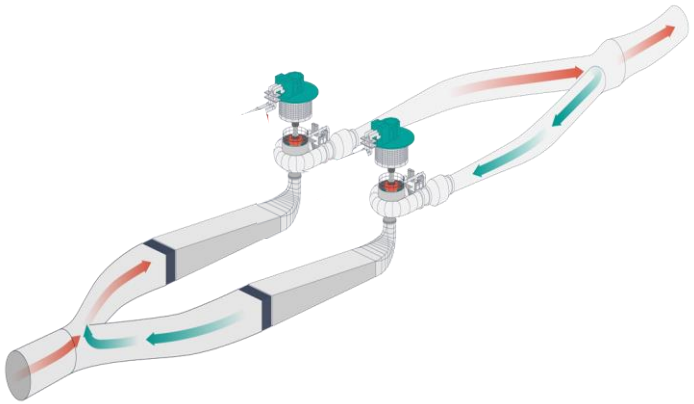


Applicability: All type of units (studied on RoR plant)

Benefits:

- ✓ Improved provision of fast frequency control services;
- ✓ Reduced wear & tear on hydraulic components;
- ✓ Enhanced regulating margin.

Hydraulic short circuit (HSC)

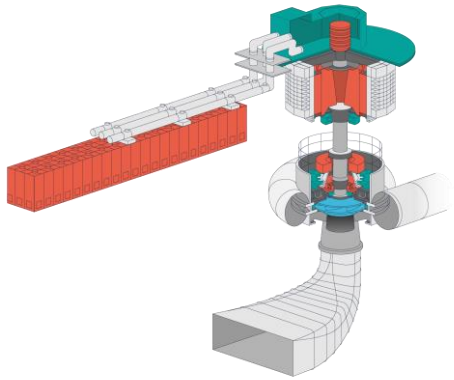


Applicability: Pumped storage plant

Benefits:

- ✓ Extended operating range and regulations in pump mode;
- ✓ Provision of frequency control services in pump mode;
- ✓ Faster switch from Pump mode to Turbine mode.

Variable speed turbines (VS)



Applicability: All type of units

Benefits:

- ✓ Extended operating range;
- ✓ Improved operations at partial load;
- ✓ Faster regulation in turbine mode; *and*
- ✓ Regulations and provision of frequency control services in pump mode.

BACKGROUND

CASE STUDIES

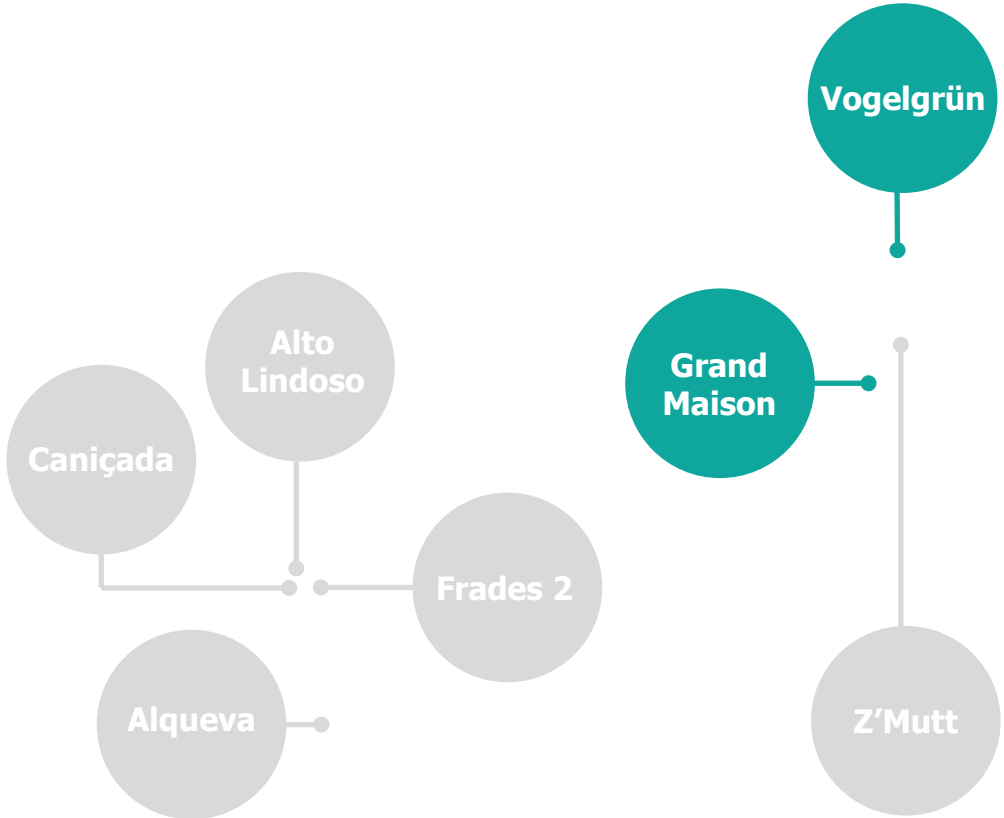
Today's presentation will focus on the experience gained at two of the XFLEX HYDRO demonstration projects:

RUN-OF-RIVER

- **Vogelgrun**: Low-head fix speed Kaplan units with moving blades.

PUMPED STORAGE

- **Grand Maison**: High-head pump storage plant with a combination of Pelton and reversible pump-turbines;



The Hydropower Extending Power System Flexibility (XFLEX HYDRO) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857832

HYDRO

Demonstrator (Vogelgrun)
Lead: EDF (Andritz)

DEMONSTRATOR

VOGELGRÜN
FRANCE

x4

35MW

RUN-OF-RIVER

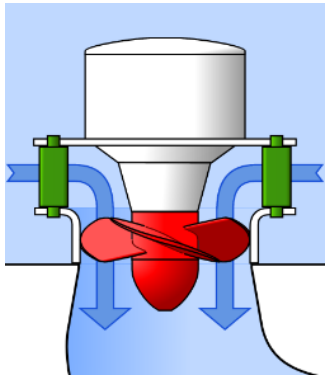
1959

BATTERY/ TURBINE HYBRID TECHNOLOGY

Vogelgrun is a run-of-river hydropower plant located in France near the border with Germany. The plant has four low-head turbines, with one unit being equipped with a battery hybrid. The battery system adds energy storage to share response capability with the hydraulic tear and use a master control to optimise flexibility services and wear and tear.

EDF cea ANDRITZ EPFL UPC ARMINES POWER VISION ENGINEERING MINES ParisTech PSL

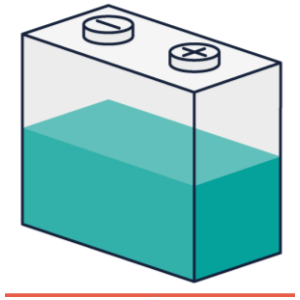
VOGELGRUN: THE RATIONALE



- Energy Intensive
- Slower dynamic response
- High maintenance costs
- Affected by regulation needs

Fast regulation
(initial service provision)

SOC management
Slower regulation

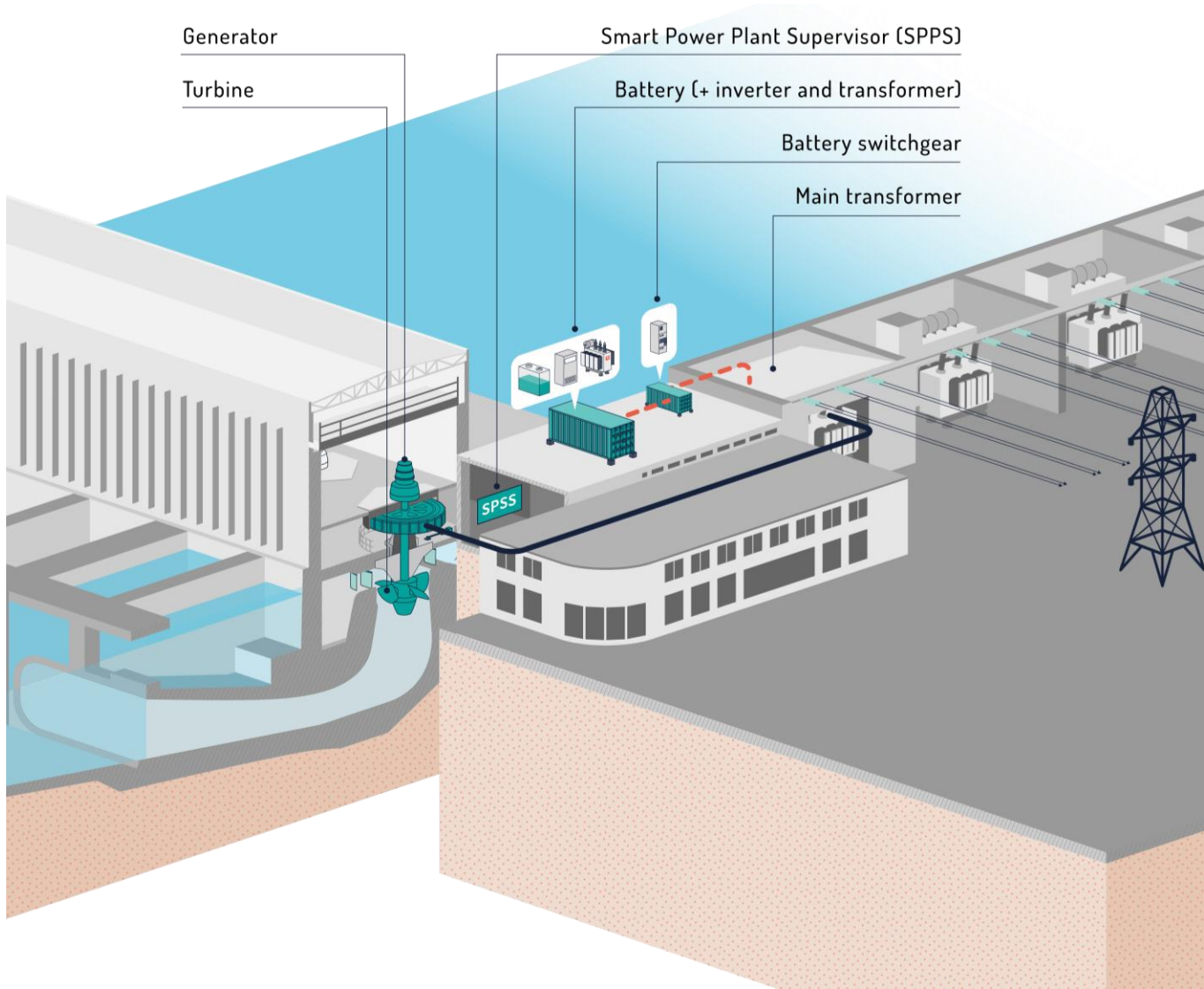


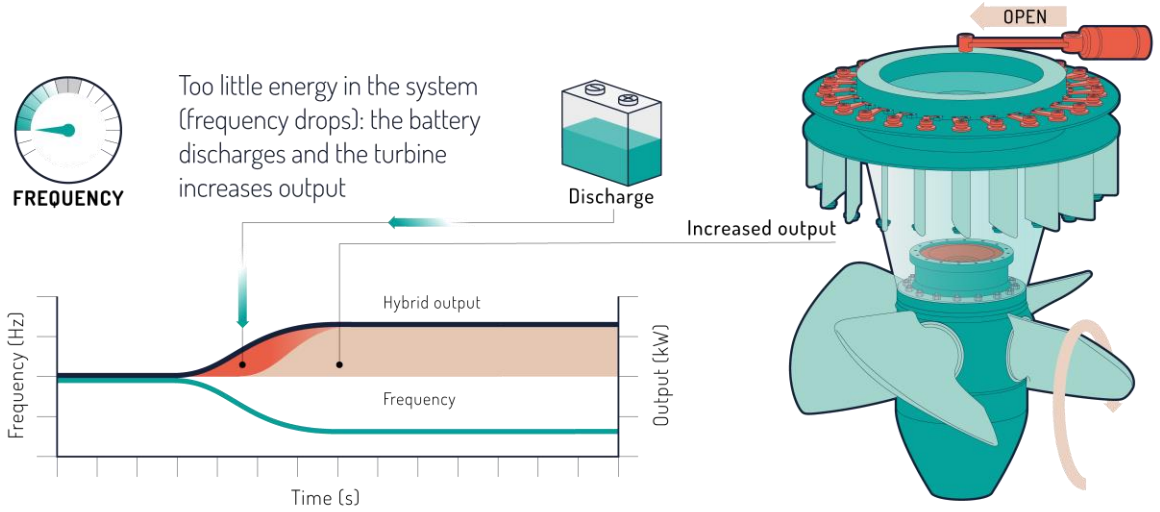
- High efficiency
- High dynamic response
- Limited energy reserve
- Provides regulation services

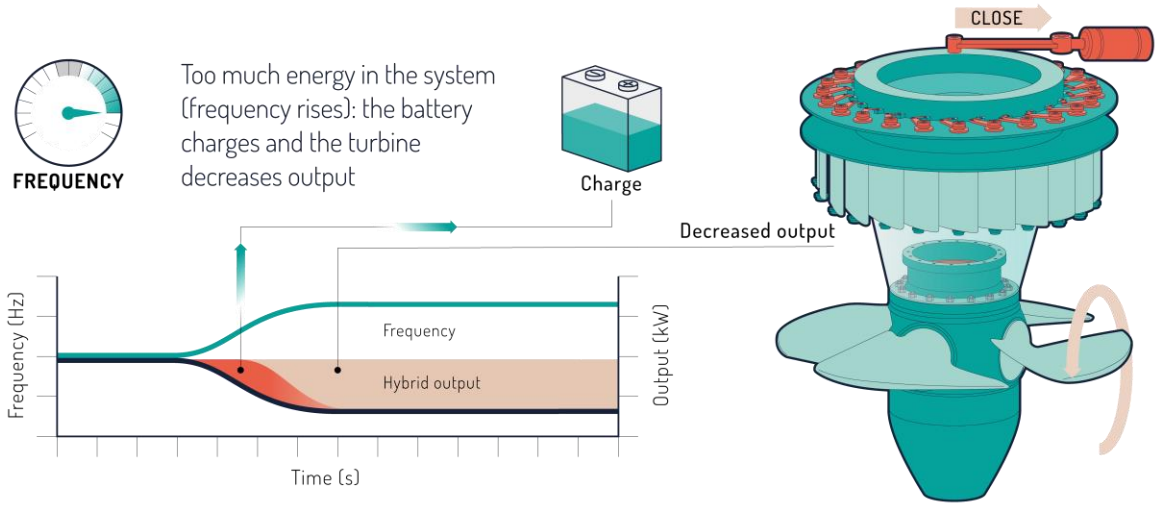
OBJECTIVES

Primary objective:

- Improve provision of Frequency Containment Reserve (FCR).
- Reduce turbine wear and tear (and quantify it).
- Minimize CAPEX of the solution







THE SOLUTION IMPLEMENTED

VOGELGRUN Hybrid Layout

- One turbine (35 MW) hybridised with a small battery (0.65 MW/0.3 MWh)
- SPPS technology:
  - Hybrid controller (turbine + battery set point)
  - Digital twin (unit status)

VOGELGRUN: RESULTS

- Reduction of regulation carried out by the mechanical parts (because of FCR provision): 8 to 10 times (despite the small size of the BESS applied; 1.9% of the turbine capacity)
  → Great improvement on the turbine reliability

- Expected time until end of life of critical components (ex: blades bearing) can be extended by of a factor of 3x.
  → Reduced need for maintenance and downtime;

- Provision of FCR service of the hybrid unit was improved in terms of dynamic response and it is now compliant with local grid code.

Additional notes:

- Carefully choose the algorithm splitting the power set points to the BESS and the turbine!

- Hybridisation of the Kaplan unit was proven more effective on older units. It should be considered as an opportunity to extend the remaining life of aged units.

HYDRO

DEMONSTRATOR

GRAND MAISON
FRANCE

x8

150MW

x4

150MW

PUMPED STORAGE

1986

HYDRAULIC SHORT CIRCUIT (WITH PELTON) TECHNOLOGY

Situated in the French Alps, Grand Maison is Europe's largest pumped storage facility. Equipped with 12 units, XFLEX HYDRO will demonstrate hydraulic short circuit using new turbine runners and automation techniques, for advanced control and efficiency.

Key Objectives:

- Integrate hydraulic short circuit in a very high head PSH plant.
- Improve provision of **Automatic Frequency Restoration Reserve** (aFRR) service.

EDF Hes·so Haute Ecole Spécialisée de Suisse occidentale GE EPFL POWER VISION ENGINEERING

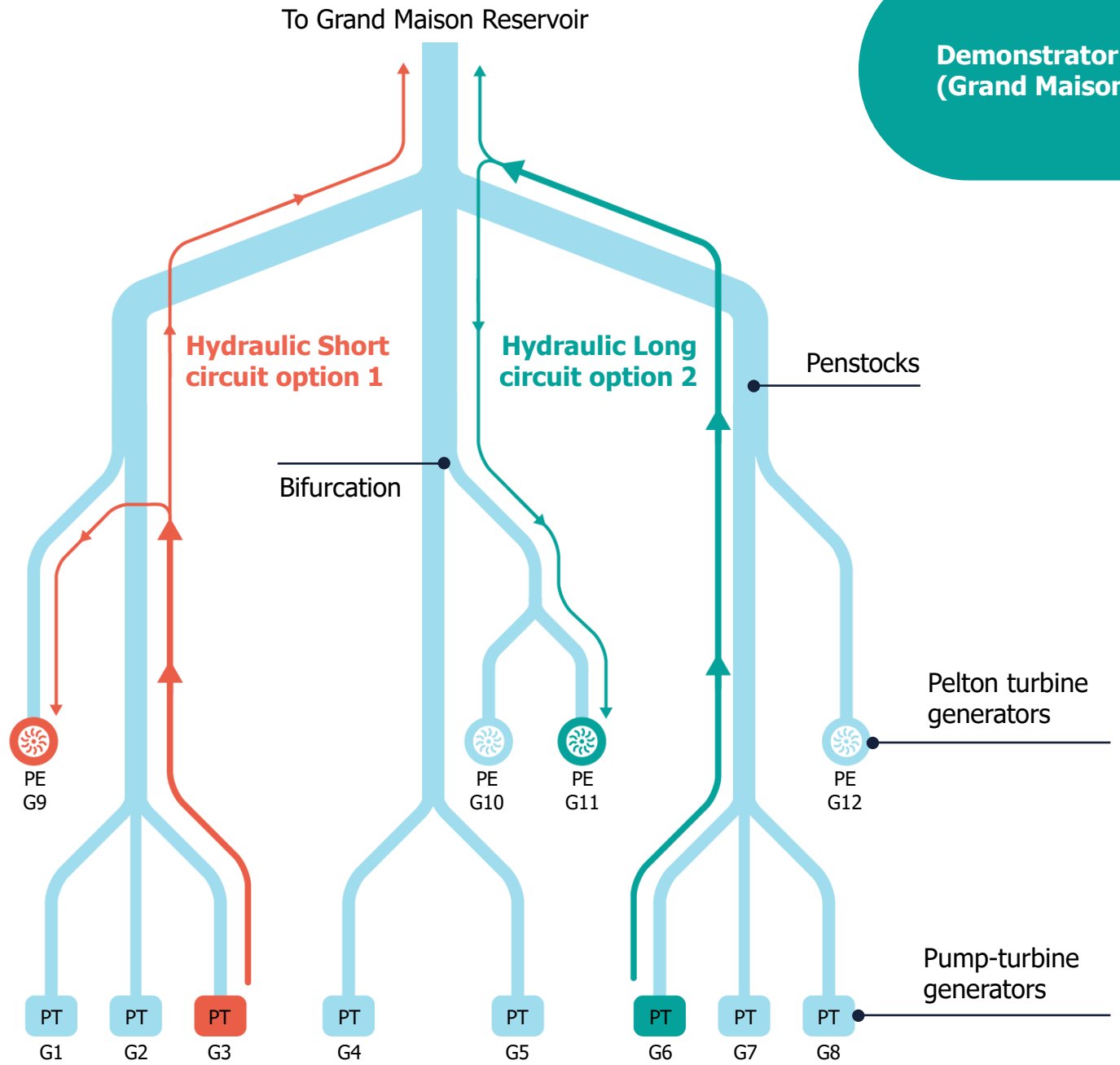
GRAND MAISON

INITIAL CONSIDERATIONS – HYDRAULIC SHORT CIRCUIT

- Units not designed for HSC
- Multiple option to operates pumps and Pelton units together
  - Short route or long route
  - Bifurcation or Trifurcation

2 hydraulic short circuit options studied:

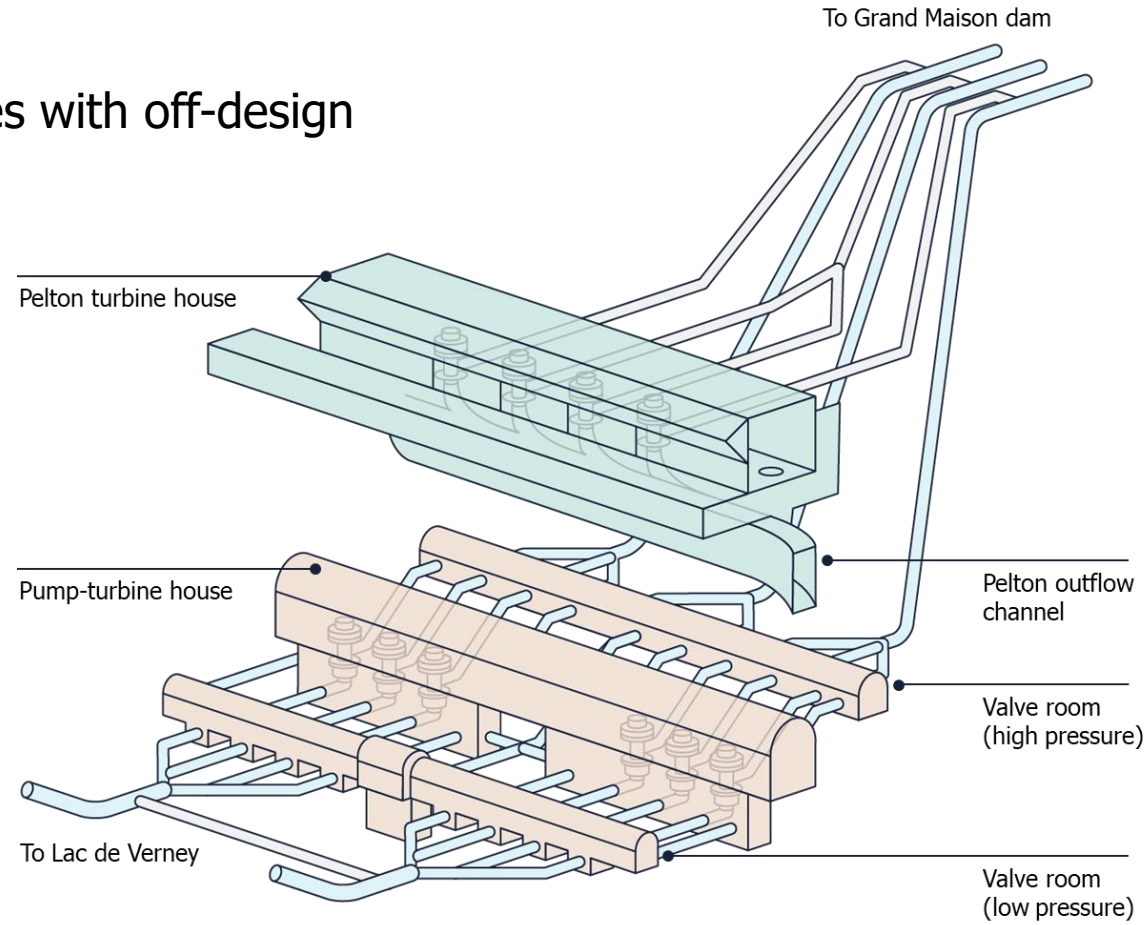
Option 1 - Short route & bifurcation
Option 2 - Long route & trifurcation



GRAND MAISON

INITIAL CONSIDERATIONS – HYDRAULIC SHORT CIRCUIT

- Extensive CFD analysis and simulations to detect issues with off-design operations
  - Check hydro transient behaviour
  - Run Emergency Shut Down scenario
- Demo includes a digital twin of the whole scheme



GRAND MAISON – RESULTS

RESULTS FROM CFD ANALYSIS

- No critical risk identified & power plant can operate safely in HSC

RESULTS FROM OPERATIONS

- HSC in service since 18 Sept 2021
- HSC proved to be relatively cheap to implement and also easy to operate
- 56% of pumping time was performed in HSC (during 2022)
- In 100 days of services HSC saved over 10,000 kgCO2 as it avoids gas plant utilisation

Predominantly used to provide regulating power during low demand periods and the plant is in pumping mode

XFLEX HYDRO

Do we have the regulatory framework to support the development of hydropower flexibility?

XFLEX HYDRO

POLICY RECOMMENDATIONS

1. Recognise Hydro Flexibility as an Essential Service to Achieve a Successful Energy Transition
2. Remove Regulatory Barriers for Unrestricted Implementation and Operation of Hydro Flexibility Technologies
3. Provide Remuneration Mechanisms Enabling Investment in Flexibility
4. Facilitate Cross-Border Collaboration for Efficient Exchange of Flexibility Services
5. Streamline Licensing Renewals for Optimised Hydropower Operations
6. Conduct System-Level Analysis to Anticipate Future Flexibility Needs
7. Promote Supporting Mechanisms for the Modernisation of Ageing Hydropower Infrastructures

FINAL PUBLICATION

- Guidelines to the sector
- Barriers to implementation
- Policy recommendations
- Research & Innovation needs
- Road map to flexibility

SCAN ME

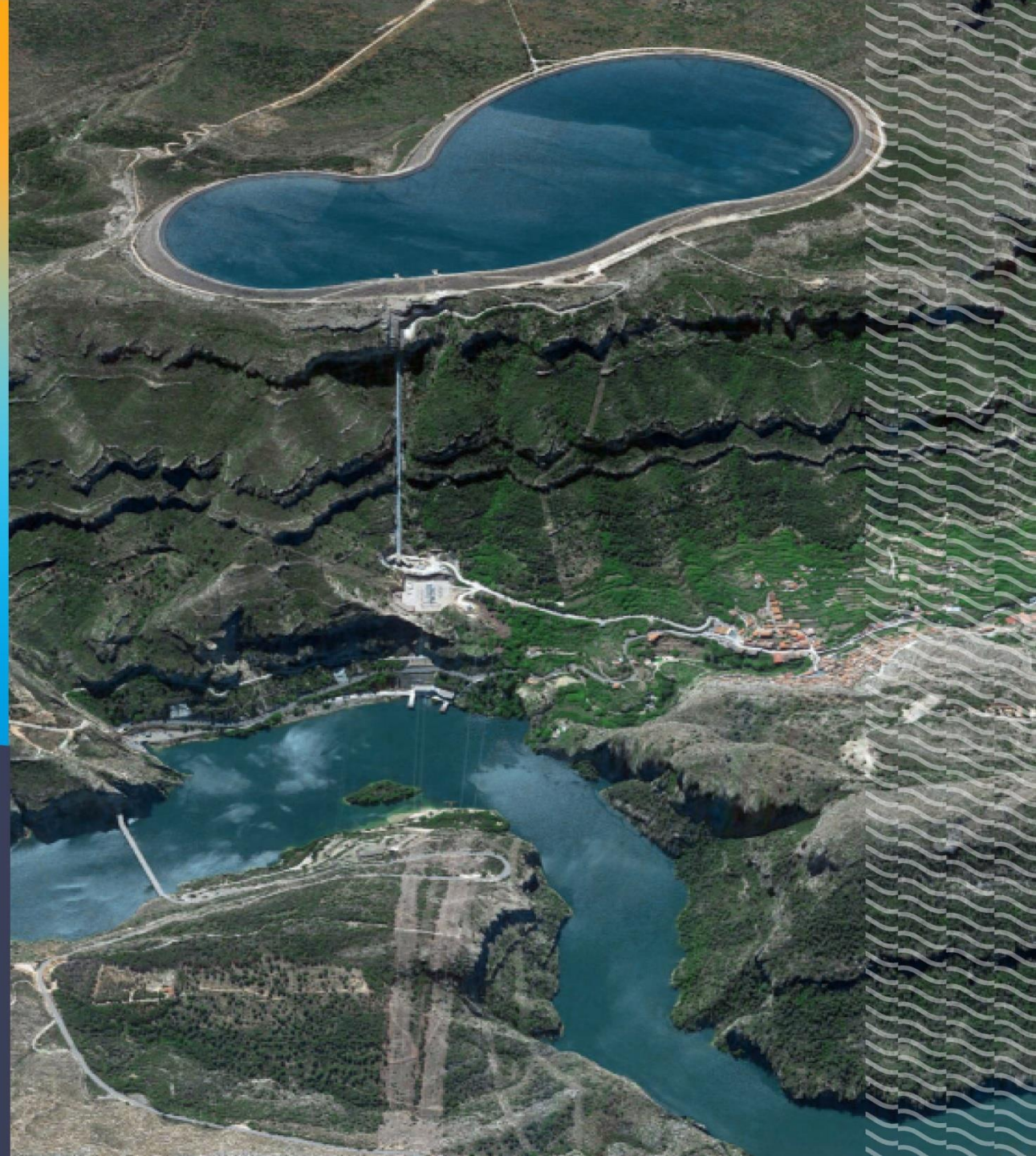
The Hydropower Extending Power System Flexibility (XFLEX HYDRO) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857832.

iha international hydropower association

XFLEX HYDRO

PARIS | SEPTEMBER 2025

International Forum Pumped Storage Hydropower



Register and get updates!

hydropower.org/IFPSH2

membership@hydropower.org

THANKS – QUESTIONS?

HYDRO

Demonstrator Review (Alto Lindoso)
Lead: EDP CNET (GE)

DEMONSTRATOR

ALTO LINDOSO
PORTUGAL

x2

317MW

RESERVOIR STORAGE

1992

ENHANCED FIXED SPEED (HIGH HEAD) TECHNOLOGY

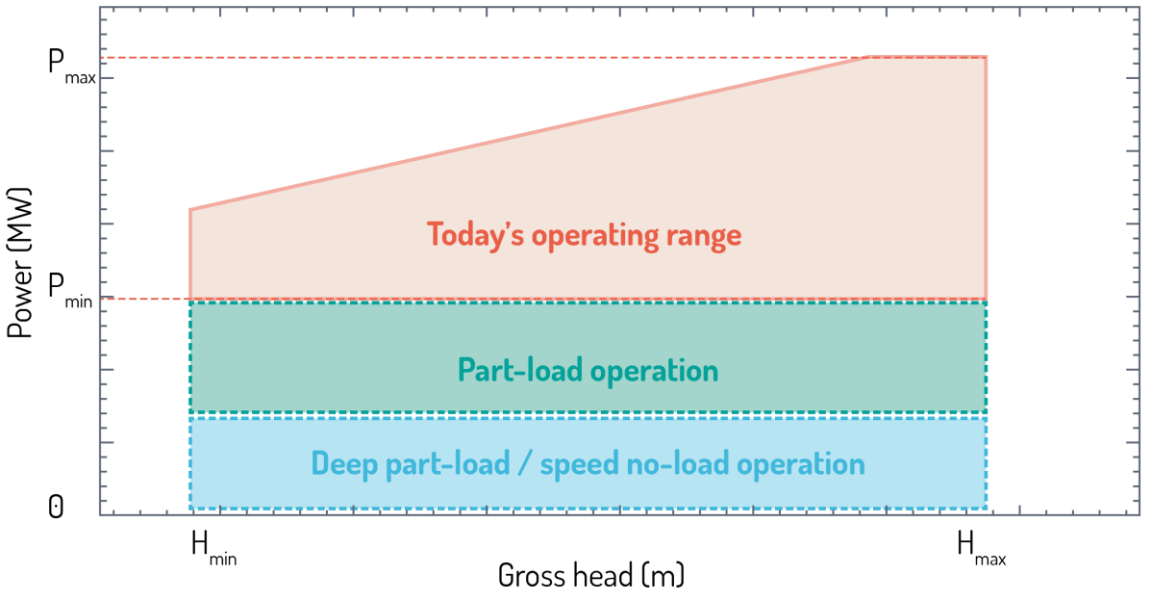
Alto Lindoso is a reservoir storage plant in Portugal, with 110m high dam and two high-head Francis turbines.

Key Objectives:

- Evaluate low CAPEX opportunities to enhance services at an existing reservoir storage plant with high head, 317 MW Francis turbines. In particular, extend the operating range targeting an almost continuous power output from near zero to rated power.
- Use advanced control based on SPPS to adapt and optimise plant dispatch under various criteria (efficiency, wear and tears, maintenance, etc.).

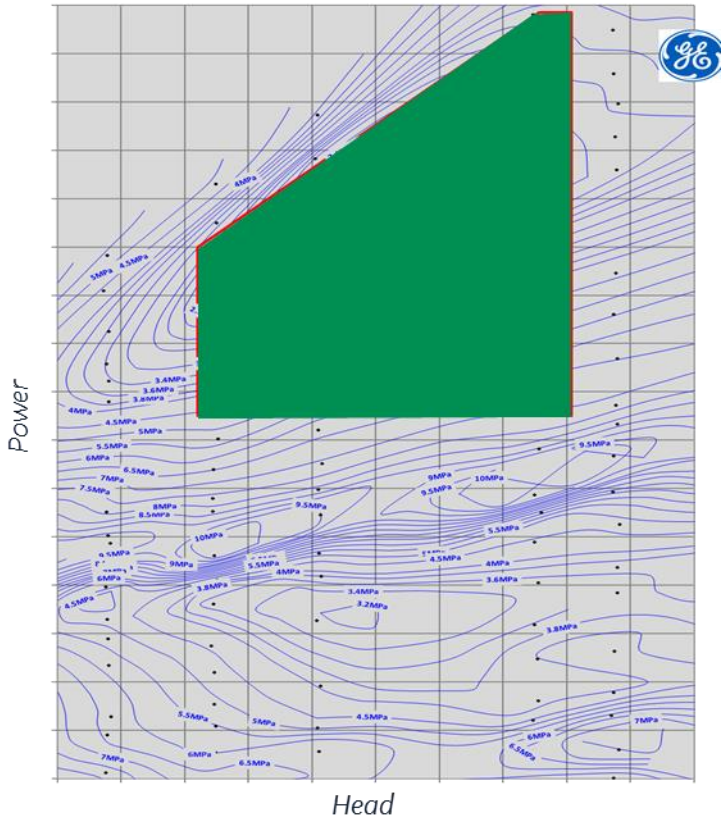
ALTO LINDOSO
OPERATING RANGE EXTENSION OF HYDROELECTRIC UNITS

- Turbine are usually designed to operate between **50%** and **100% of the rated power**.
- To provide flexibility and grid balancing, units will need to be **ramped up and down** over an operating range. Often with consecutive **start & stop** procedure during the same day.
- Studies to identify the risks of operating at low power have been undertaken; higher efficiently and safe operating across a wider band **from 0 to full power** (P)

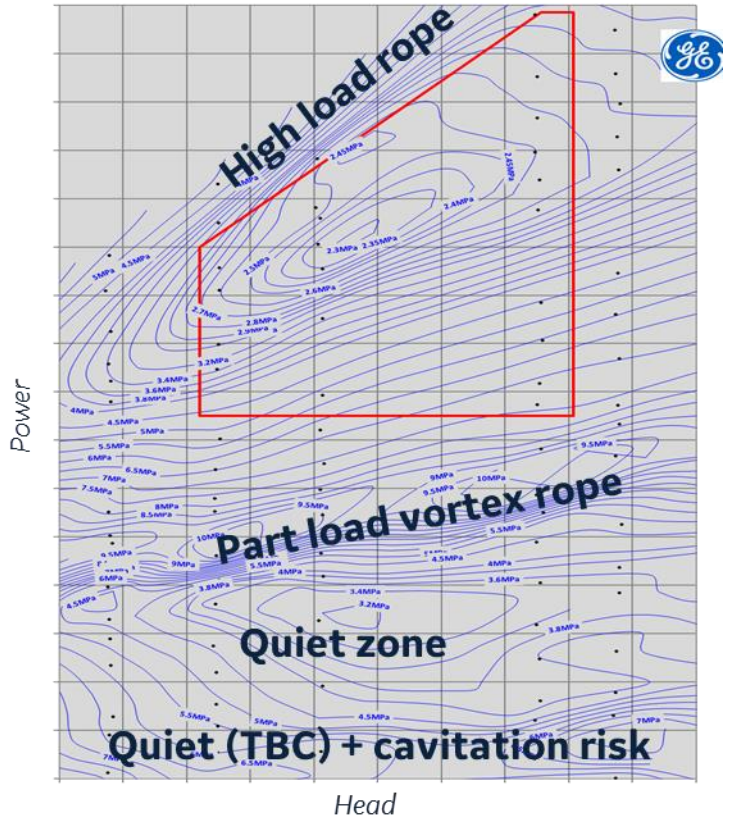


ALTO LINDOSO
EFFECTIVE OPERATING RANGE EXTENSION

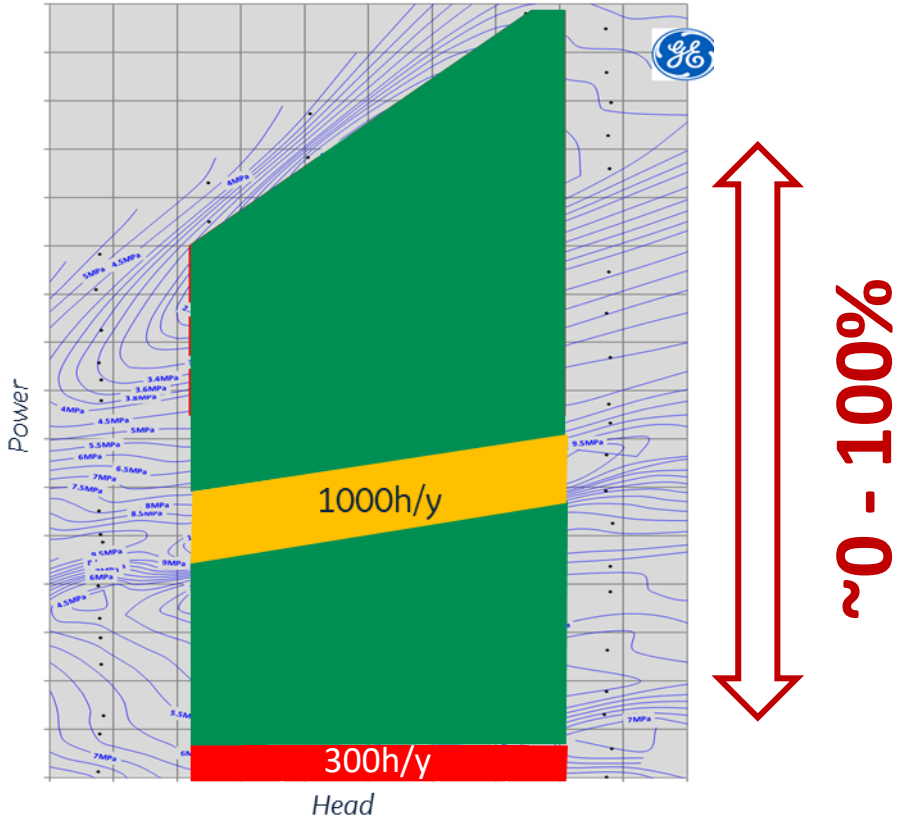
Initial operating range



Damage evaluation



2022 operating range



ALTO LINDOSO: RESULTS

The project demonstrated that the unit can operate at deep partial load without damaging the hydraulic components.

This has the following advantages:

- Each 317 MW unit has now an increased regulating margin of circa +/-150 MW (x2 the original regulating zone)
  → Enhanced range for the provision of ancillary services;
  → Reduced the number of start & stop sequence and improved the operating reserve available to the operator/TSO.

- It can operate at a very limited flow
  → Better upstream and downstream water management;
  → Better resilience against extreme meteorological conditions;

- Overall enhanced plant flexibility → Better participation in spot markets.