STOR-HY

Innovative Storage Technology and Operations in Hydropower

Seminar: Harnessing Hydropower's Energy Storage and Flexibility for the Energy Transition

2nd October 2025

Funded by the European Union under Grant Agreement No. 101172905. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the CINEA can be held responsible for them.

Funded by the European Union

Overview of STOR-HY

- Pumped storage hydro
- The project STOR-HY
- The demonstrators
- CADS
- STOR-HY strategy
- Summary

Pumped Storage Hydro

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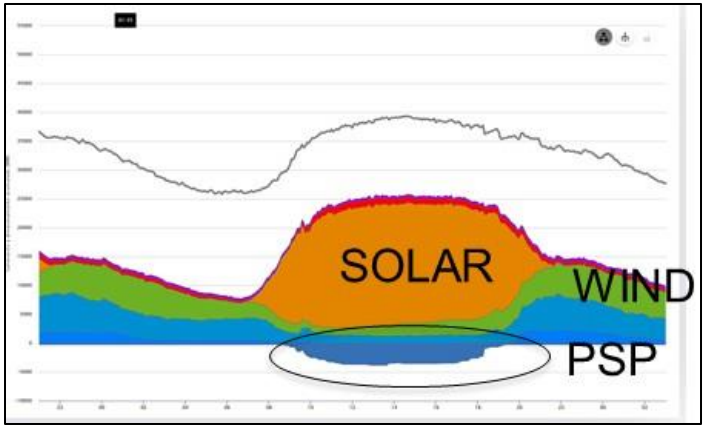
PSH nowadays

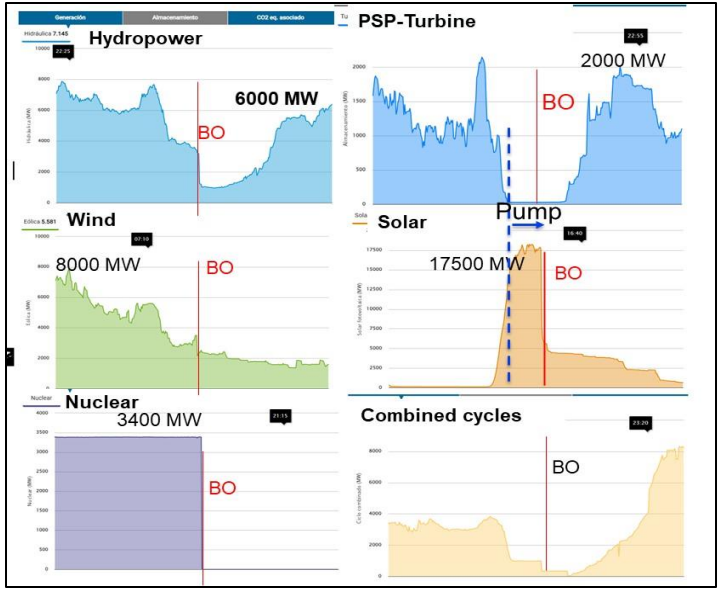
- According to IHA, around **200GW** installed and **9 TWh** of storage capacity.
- Accounts for **more than 90%** of the world's **long-duration electricity storage** capacity

27/06/2025-SPAIN



- Further **increase of PSP** is fundamental for:
  - Accelerate deployment of wind and solar avoiding **curtailments**
  - Provide **flexibility** in energy generation
  - **Synchronous inertia** with **Black Start** capabilities
  - Stabilise electricity market prices

28/04/25-SPAIN Black Out &Start



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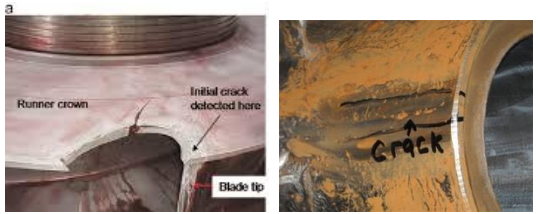
Operation of PSP in Europe

- **Flexibility** & high penetration of **Wind and Solar**:
  - Multiple **start-stops**
  - Faster time responses
  - Short term availability
  - **Ancillary services** provision (which is sometimes not properly paid)

→ Flexibility & Adaptability of PSP

- **Aging** of PSP in EU:
  - Increased number of **failures**
  - Higher maintenance **costs**
  - Longer **maintenance** periods



→ Wear & Tear

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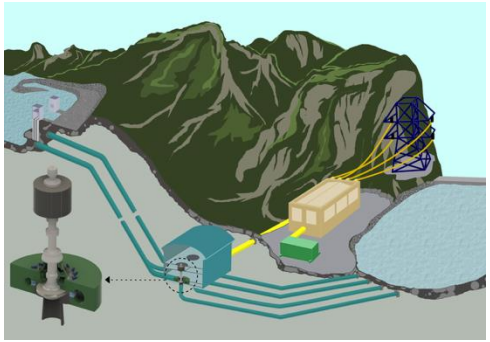
Geographical barriers of PSP

- Best **locations** have been already taken (economic and technological)



- New technologies to extend the **potential locations** of PSP: sediments, salt water, coal mines

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STOR-HY: Innovative Storage Technology and Operations in Hydropower

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Consortium

18 members:

- 7 from Spain
- 4 from France
- 3 from Portugal
- 1 from Germany
- 1 from the Netherlands
- 1 from Belgium

Associated countries:

- 2 from Switzerland
- 1 from Norway

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Universities and RDI centers (8)

NEW, FAEN Fundación Asturiana de la Energía, Hes·so VALAIS WALLIS, INESCTEC, GRENOBLE INP UGA, NORCE, UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH, UNIVERSITY OF TWENTE.

Utilities (3)

EDF, edp, hunosa

Manufacturers (2)

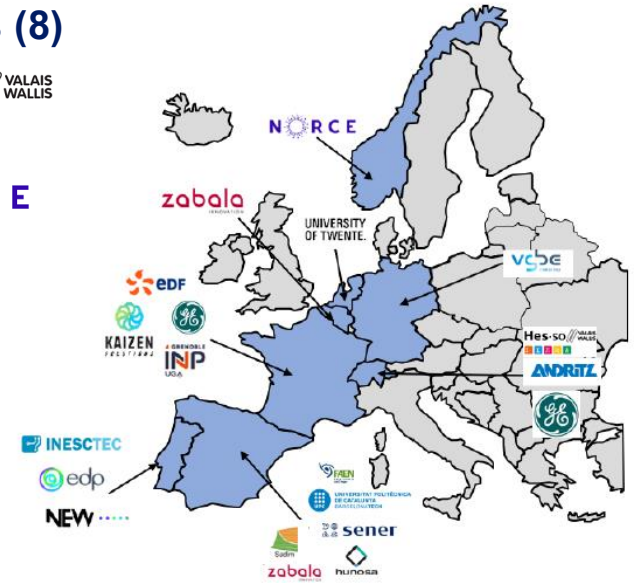
ANDRITZ Hydro, GE

Industrial developers (3)

KAIZEN SOLUTIONS, SADIM, sener

Exploitation and dissem. (2)

vcbe ENERGY IS US, zabala INNOVATION



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PSP Requirements

NEW

UNIVERSITY OF TWENTE.

Demonstration TRL 7/8

LCA & Sustainability

Communication

zabala INNOVATION

Exploitation

vgbe ENERGY IS US

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Targeted outcomes for STOR-HY

Start point: To understand the tecno-economic, regulatory, environmental and social **requirements for new PSP equipment and tools** (WP2)

Outcomes of STOR-HY will target

1. CAPEX and OPEX **reduction** of existing PSP
2. Increasing operational capacities of PSP: Adaptation to **harsh conditions** to increase the **geographical availability**
3. Improve **digital operational tools** for greater efficiency
4. Boost **durability and recyclability** of components
5. **Replicability** and scalability of the developed technologies

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Demonstration of technologies

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Le Cheylas

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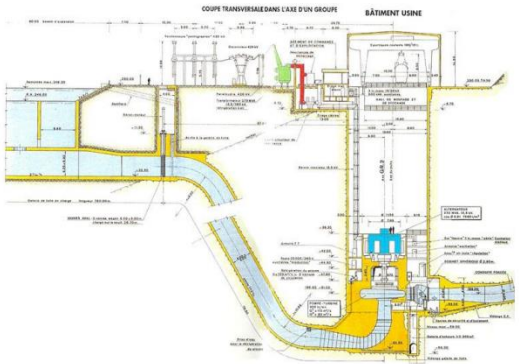
Le Cheylas



Basic data

- 2 units
- 250 MW each
- H= 250m
- Q= 100m^3/s

Partners involved

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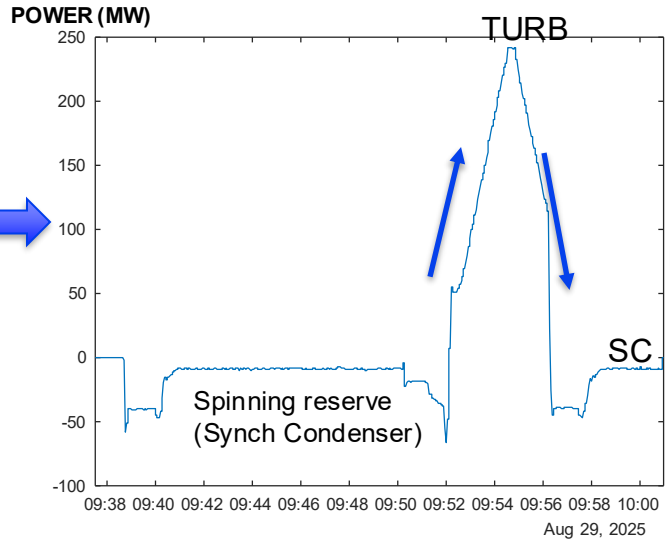
Le Cheylas- Adaptation to Market

- Hydropower is continuously increasing its flexibility services

MARKET REQUIREMENT

Since 2025, hydropower assets have to respond in the **quarter hour** market.

LOW CAPEX UPGRADE



OUTCOMES

Win-win situation :
+ Avoiding start-stop cycles
+ Spinning reserve on the grid
+ Fast reaction time

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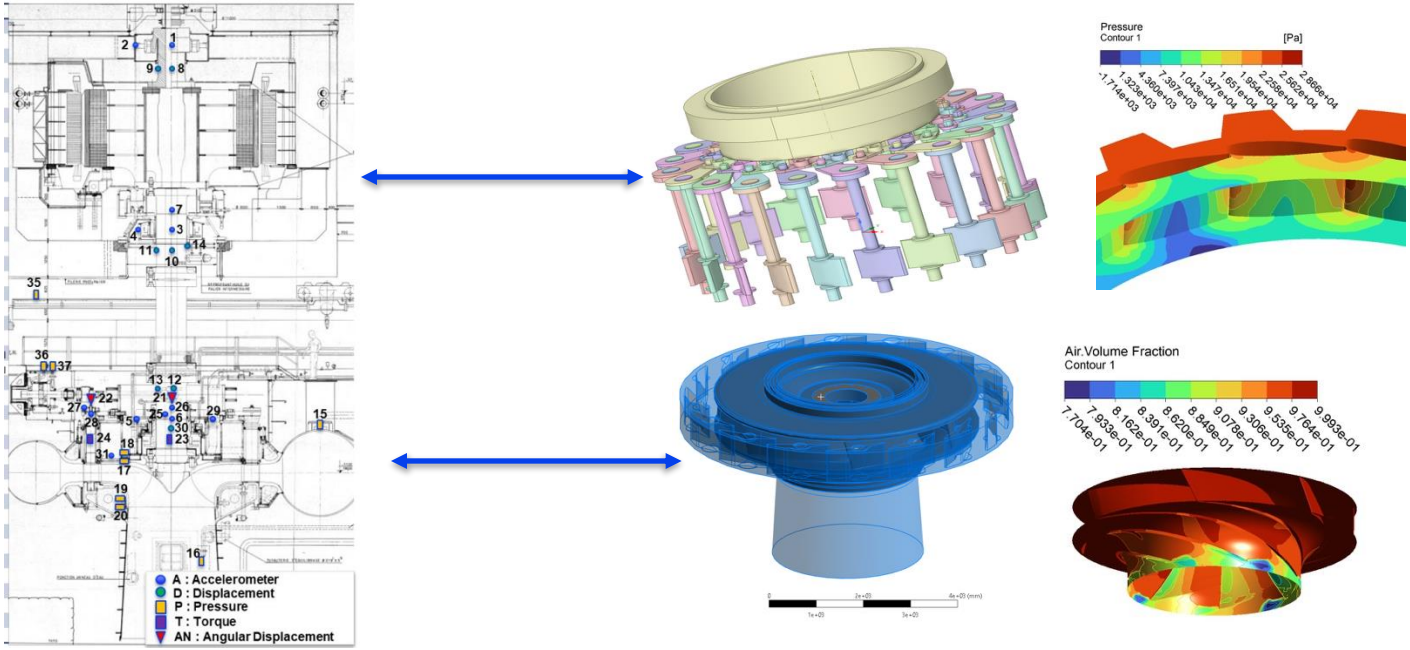
STOR-HY CONTRIBUTION

- **Wear and Tear** assessment based on advanced monitoring+ simulations



- **Real time** monitoring & Cost of transient operations through **CADS**

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Vouglans-SM-C

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Vouglans- Saut Mortier- Coiselet

Basic data

- 3 reservoirs (cascade)
- Main: 1 PT VG-SM, 72 MW
- 4 units VG-SM
- 2 units SM-C + new pump

Partners involved

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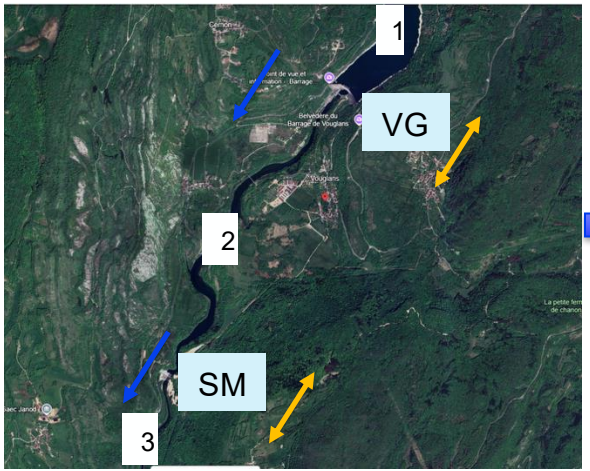
VSMC- Management of cascade pumping

- There is an increasing interest in EU to **convert conventional hydro to PSP**

REFURBISHMENT EXISTING PSP

A new variable speed pump is installed in C-SM. This enables also the pumping SM-VG .

LOW CAPEX UPGRADE



OPTIMIZATION

+ Energy storage
+ Water management
+ Market
+ Wear and Tear
+ Enviromental/societal (ReHydro project)

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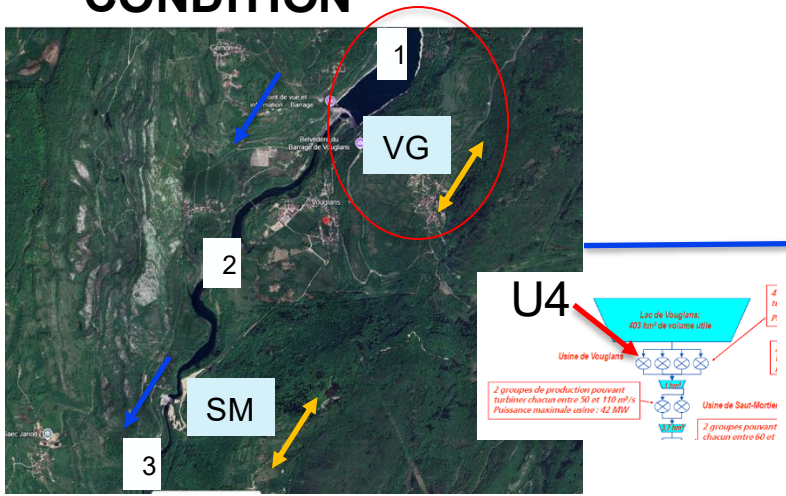
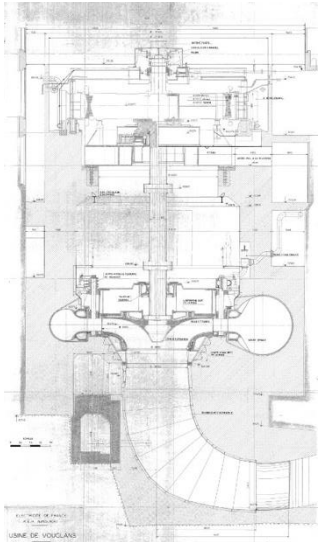
VSMC- Unit 4 of Vouglans

- **Start-up as pump** is one of the critical phases of the operation of PT

NEW OPERATING CONDITION

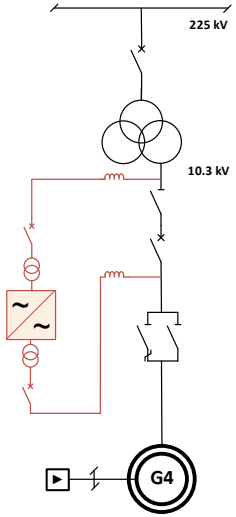


MECHANICAL



- **Wear and Tear**
- **CADS**

ELECTRICAL



- Back to Back vs Soft Starter

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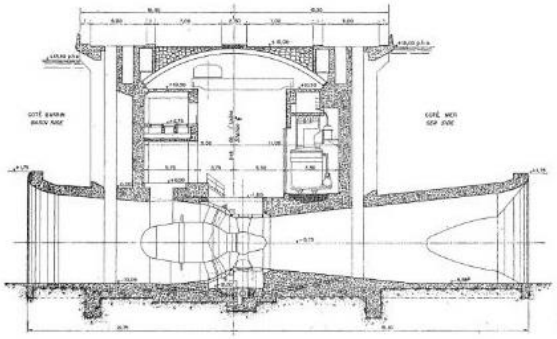
La Rance

STOR-HY

La Rance



Basic data

- Only tidal in Europe (salt water)
- 24 bulb turbines of 10 MW
- 4 start and stop per day

Partners involved

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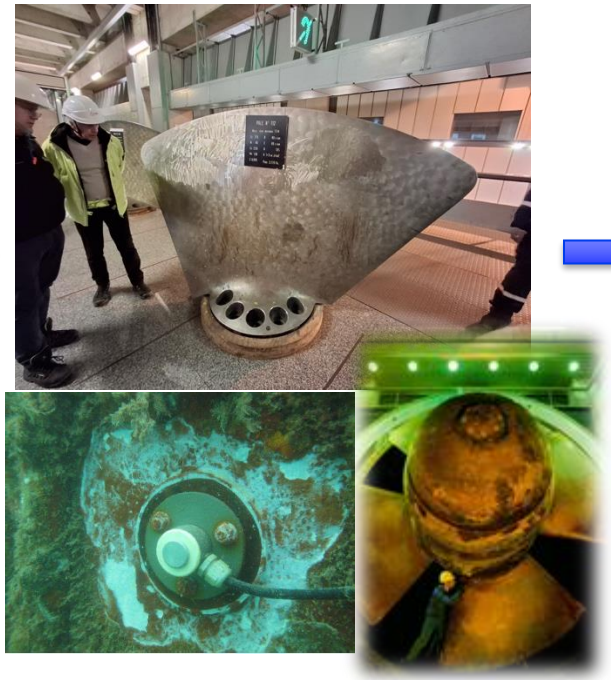
La Rance- Future Salt Water PSP

- **PSP in Sea- Water** could unlock a wide potential for **new PSP**

PSP in Salt Water

- Only one known case already decomisioned (**Okinawa**)
- **Chira-Soria** (through desalinization)
- Projects: La Reunion, Ireland, Australia, Estonia….

“Best” test bench in EU



In STOR-HY

+ **Biofouling** management
+ Sea water **sediment** monitoring
+ **Corrosion** mitigation

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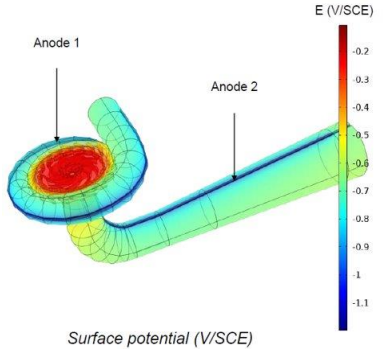
La Rance- Future Salt Water PSP

- **STOR-HY is performing research** on the following aspects

Corrosion & cathodic protection



Special coatings for corrosion & Biofouling

Biofouling

Coupling of technologies & easy surface cleaning

Sediment monitoring

Robust sensing technologies for sediment transport

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Pozu Figaredo

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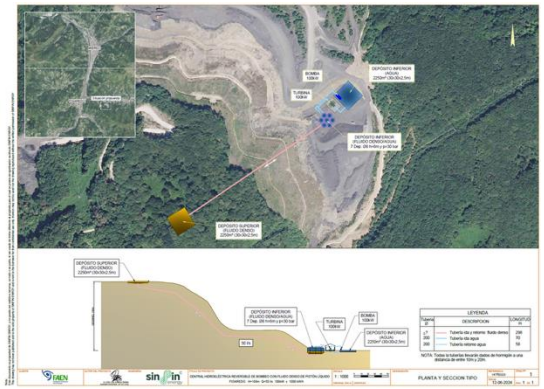
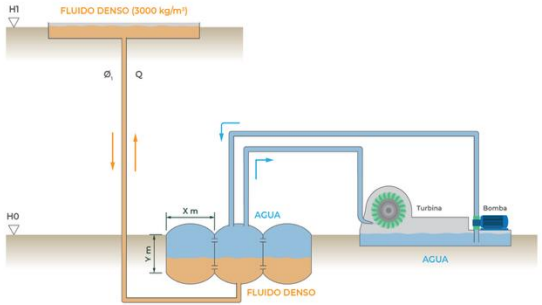
Pozu Figaredo





Basic data

- 100 kW scale
- One pump and one turbine
- Using dense fluids

Partners involved

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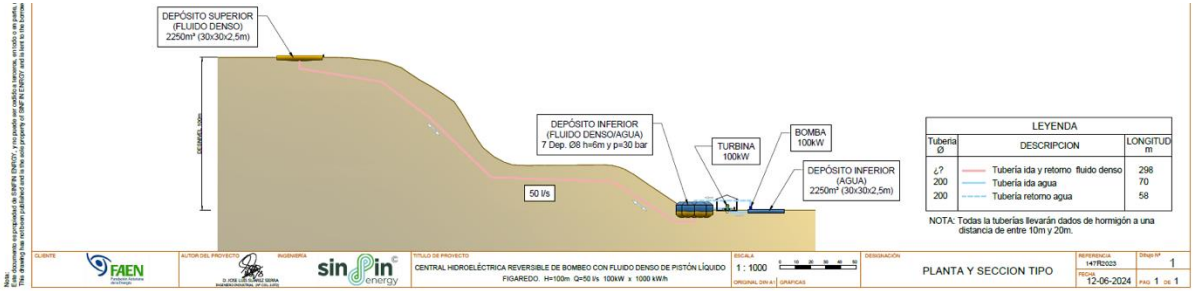
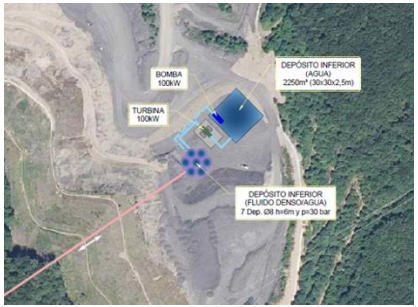
Pozu Figaredo

- EU Regions such as Asturias are transitioning from a mining-based industry to clean technologies, supported by the Just Transition Fund





- During STOR-HY: Small coal mine PSP demonstrator (open pit) with dense fluid

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Pozu Figaredo- STOR-HY contributions

Technical track

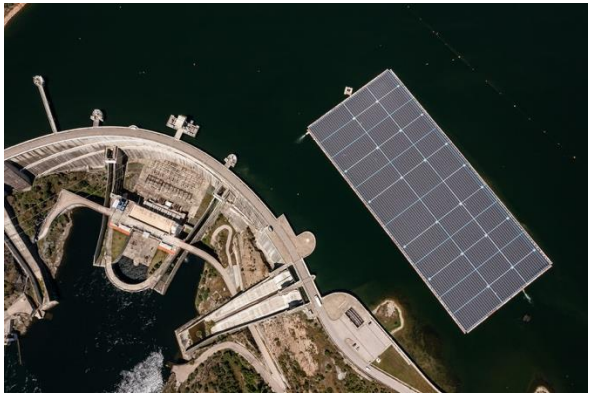
- 1D dynamic model of the plant: Influence of the fluid density
- EMS adapted to the environment

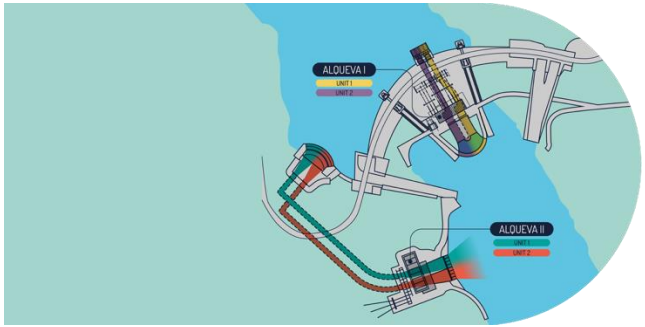
Upscaling to MW scale

- Reporting of the project
- Viability of the MW scales
- Alternative economic models for former coal mining areas

Alqueva

Alqueva





Basic data

- 4 units (I and II)
- P=130 MW
- H= 72 m

Partners involved

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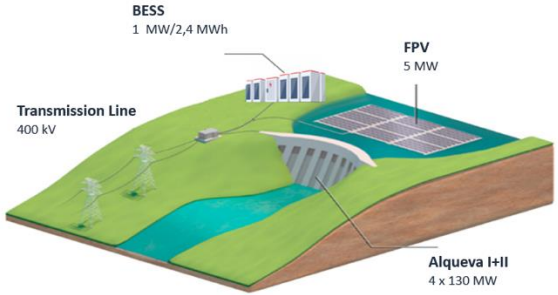
Alqueva- Management of hybridized PSPs

- **Hybridizing** PSP can lead to increased **flexibility** and **availability**

TRIPLE HYBRID PSP



+ Nowadays, 3 separated assets

Future market requirements

+ **Start/stops** drastically increased
+ Operation from 0% to 100%(XFLEX)
+ **Fast reaction** time

In STOR-HY

+ **EMS** for several market operations
+ Effects of new operations on **W&T**
+ Propper controller for the **triple hybrid** system
+ Propper **sizing** of PV and BESS

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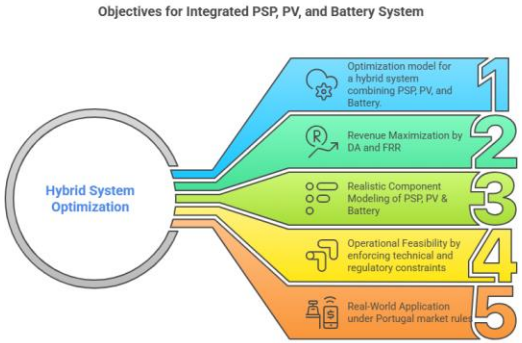
Alqueva- STOR-HY contributions

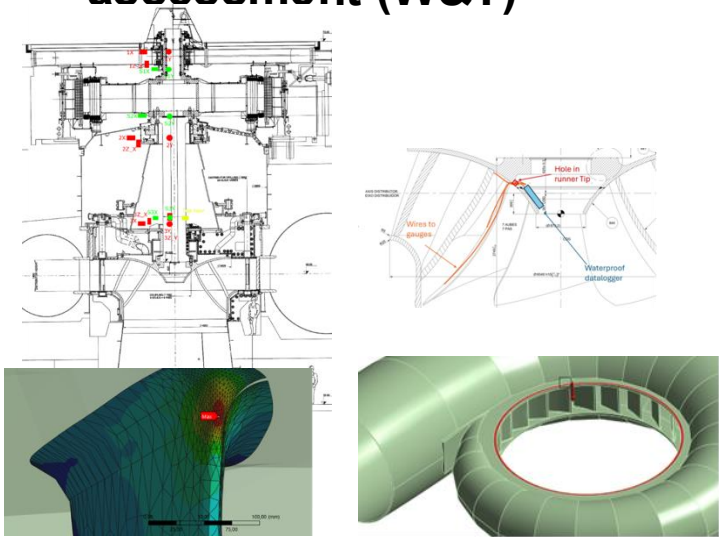
- **Flexibility & hydro mechanical limits** will be assessed together

EMS Development



+Ancillary Services (FCR, aFRR)
+ Green Black-Start: PSP+ BESS

Hydro mechanical assessment (W&T)



+ W&T: Multiple **start/stops** &**Flexibility** on critical parts

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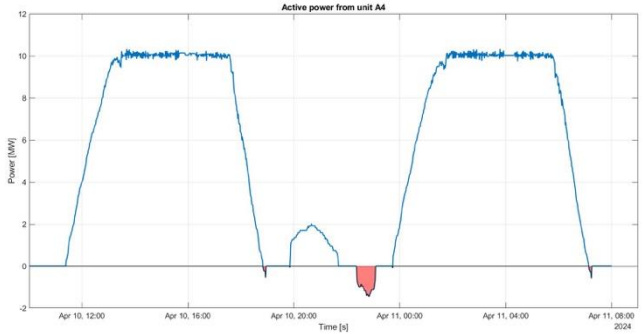
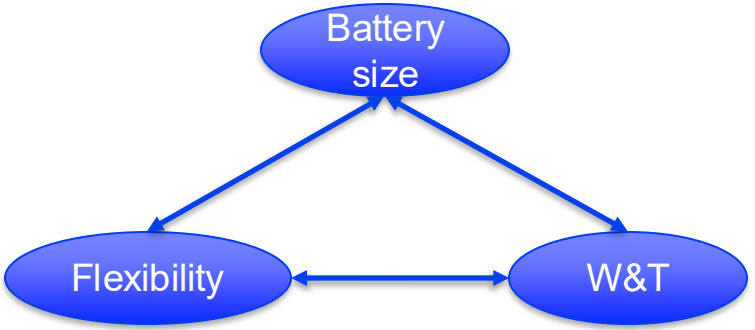
Alqueva- STOR-HY contributions

- **Hybridization** strategy will be optimized balancing **flexibility** and **W&T**

Battery sizing for Alqueva





Vilarinho das Furnas

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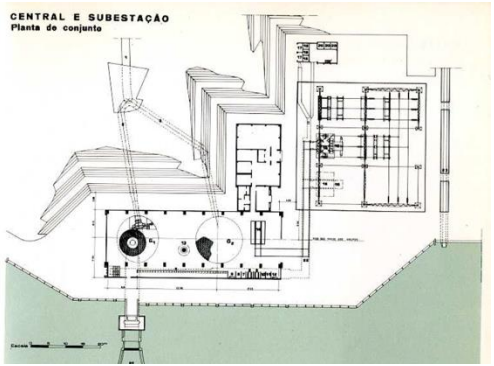
Vilarinho das Furnas



Basic data

- 2 units
- 1 Francis unit 70 MW
- 1 Multistage pump 70MW
- H= 450m

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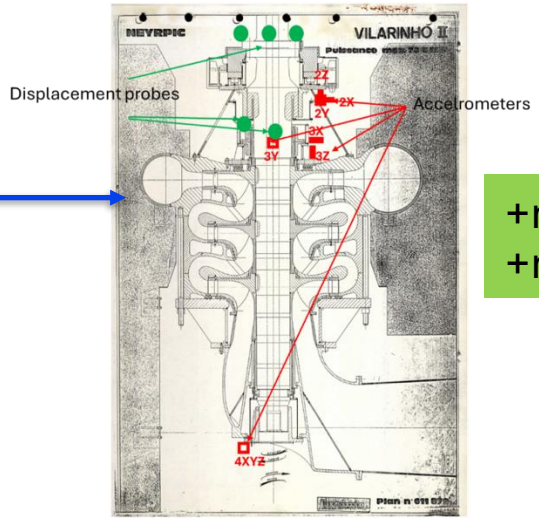
Vilarinho das Furnas

- **Multi Stage Pumps** lack of flexibility in turbine mode (non regulated).
- Approximately **19GW** (10%) of installed capacity in EU

CHALLENGE

How to **increase the flexibility** of an MSP with a **low CAPEX retrofiting**?

Multi Stage Pump



+no regulation as Pump
+no regulation as Turbine

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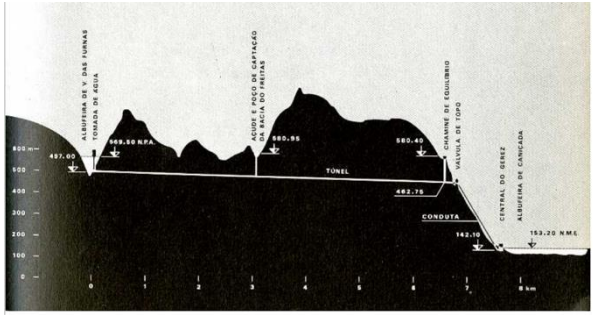
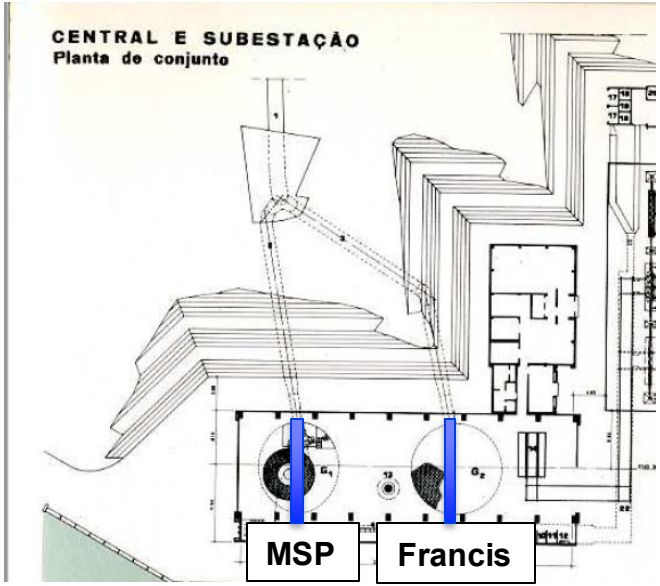
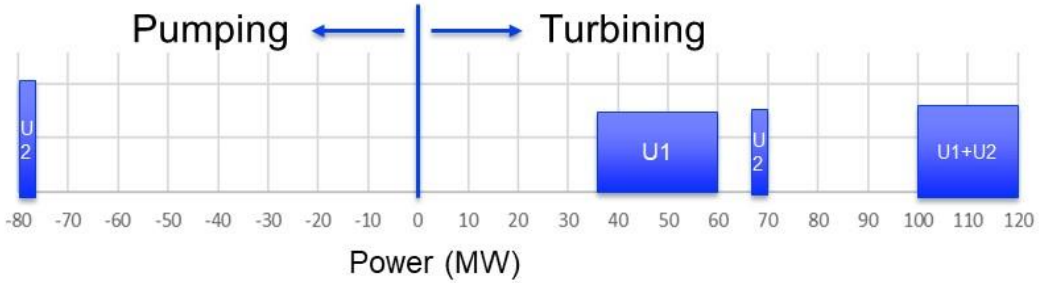
Vilarinho das Furnas

Layout





Range of the Plant



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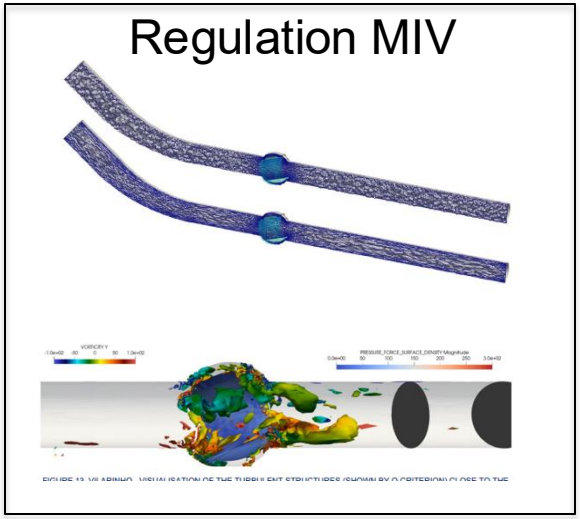
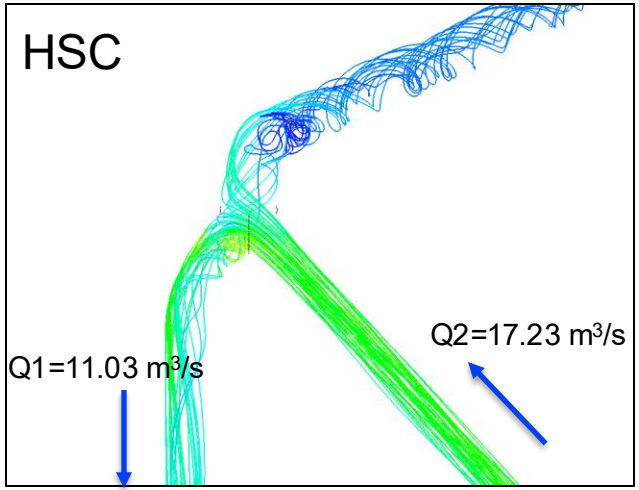
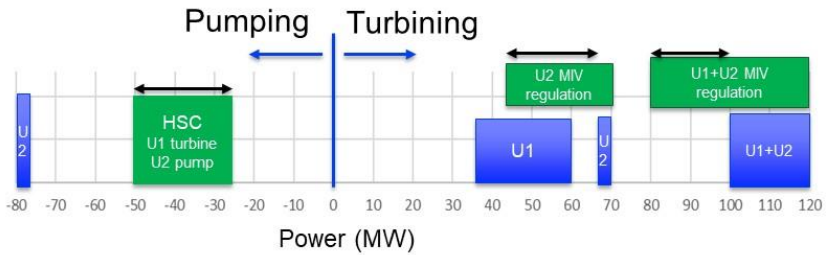
Vilarinho das Furnas

- Combination of Regulation with the **MIV and HSC**







Extended range with low CAPEX retrofitting

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CADS

The cyber-physical platform of STOR-HY

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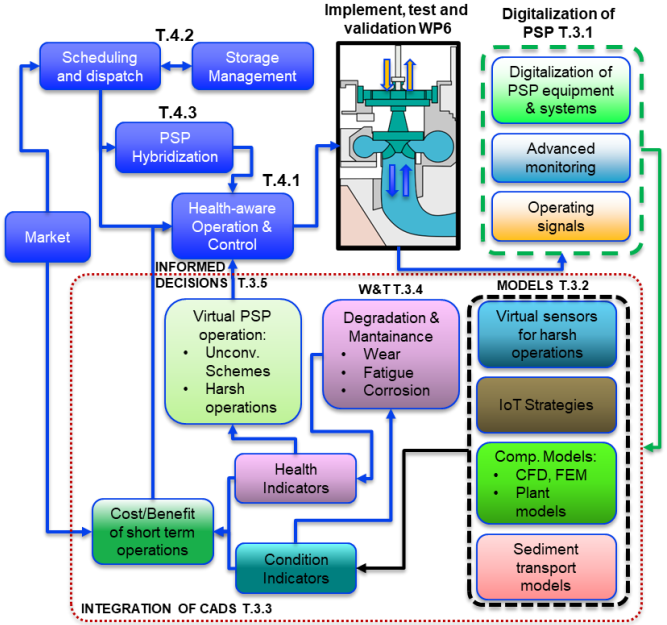
CADS: Cyber-physical Clone for Advance Decision Support

- **CADS is the common framework of STOR-HY project**



1. Creation of **a clone** of a PSP in different operating conditions and storage schemes

2. Equipment degradation and **informed decisions** for **predictive maintenance** operation

3. Modulable and adaptable to the several demonstrators

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WRAP UP

STOR-HY

Wrapping up

- STOR-HY is a EU project about **innovative storage technologies** and **operation** in Hydropower (2024-2028)
- The consortium includes 18 organizations from 8 countries
- Main **targeted outcomes** are:
  - **Reduction of CAPEX** and **OPEX** of exiting PSPs
  - Boost durability and **recyclability** of components
  - Improvement of **digital tools** for better operations and greater efficiency
  - Increasing **operational capacities** of PSPs (geographical availability)

- Developments **are being tested in the demonstrators** in harsh conditions and unconventional/innovative schemes (TRL 7/8)

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THANK YOU!

STOR-HY

Innovative Storage Technology
and Operations in Hydropower

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