

XFLEX HYDRO

Building a low-carbon, climate resilient future

THE HYDROPOWER EXTENDING POWER SYSTEM FLEXIBILITY PROJECT (XFLEX HYDRO)

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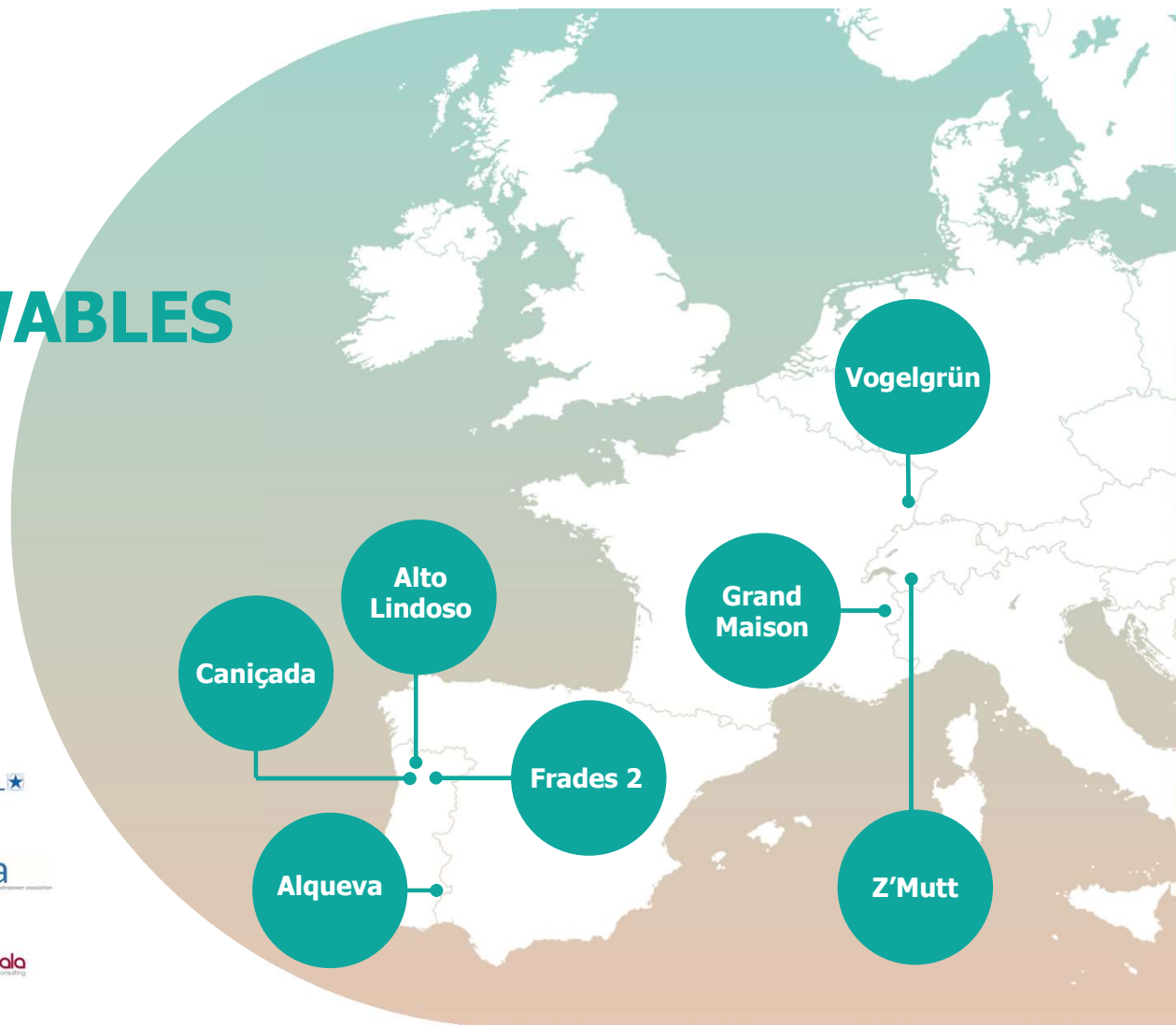
The Hydropower Extending Power System Flexibility (XFLEX HYDRO) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857832

CONTEXT

EU 32% by 2030 RENEWABLES
TARGET ALREADY MET

THE PROJECT

19 project partners



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ANCILLARY SERVICES MATRIX



- Each and every flexibility service can be addressed by hydro power
- Extended service range is within reach

		ANCILLARY SERVICES											
		SYNCHRONOUS INERTIA	SYNTHETIC INERTIA	FAST FREQUENCY RESPONSE (FFR)	FREQUENCY CONTAINMENT RESERVE (FCR)	AUTOMATIC FREQUENCY RESTORATION RESERVE (aFRR)	MANUAL FREQUENCY RESTORATION RESERVE (mFRR)	REPLACEMENT RESERVE (RR)	VOLTAGE/VAR CONTROL	BLACK START			
Sites/Timescale		0 s	< 500 ms	0.5-2 s	< 30 s	30 s - 15 min	< 15 min	> 15 min	< 1 s	N/A			
DEMONSTRATIONS	Z' MUTT	T P	T P	T P	T P	T P	T P	T P	T P	●	FS	TECHNOLOGICAL SOLUTIONS	
											VS (FSFC)		
											VS & SPPS		
	GRADES 2	T P	T P	T P	T P	T P	T P	T P	T P	●	FS		
											VS (DFIM)		
											VS & SPPS & HSC		
	GRAND MAISON	T P	T P	T P	T P	T P	T P	T P	T P	●	FS		
											FS, SPPS & HSC		
	ALQUEVA	T P	T P	T P	T P	T P	T P	T P	T P	●	FS		
											FS & SPPS		
											FS & HSC		
											FS, SPPS & HSC		
											VS (FSFC) & SPPS		
	ALTO LINDOSO & CANIÇADA	●	●	●	●	●	●	●	●	●	FS		
											FS & SPPS		
											VS (FSFC/DFIM) & SPPS		
	VOGELGRUN	●	●	●	●	●	●	●	●	●	FS Kaplan		
											FS, SPPS & HBH		
											VS (FSFC) Propeller		
											VS, SPPS & HBH		
Original terminology		Inertia		Primary frequency control (FC)		Secondary (FC)		Tertiary (FC)		Voltage control		System re-start	
Emerging frameworks		BILATERAL CONTRACTS (GB)		-		GB/IR/NORD		FCR coop.		PICASSO/IGCC		MARI	
												TERRE	
												BILATERAL CONTRACTS	
												BILATERAL CONTRACTS	
MARKET FRAMEWORK													

LEGEND

TYPES OF HYDROPOWER STATIONS

- Pumped storage plant
- PSP turbine mode
- PSP pumping mode
- Reservoir storage hydropower
- Run-of-river hydropower

TYPES OF HYDRO EQUIPMENT

- Reversible Francis unit(s)
- Francis unit(s)
- Pelton unit(s)
- Kaplan/propeller unit(s)
- Electro-chemical battery

FLEXIBILITY TECHNOLOGY

- SPPS Smart Power Plant Supervisor (XFLEX product)
- FS Fixed speed
- VS Variable speed
- VS (FSFC) VS with full size frequency converter
- VS (DFIM) VS with doubly fed induction machine
- HSC Hydraulic short circuit (PSP)
- HBH Hydro-battery-hybrid

MARKET FRAMEWORKS

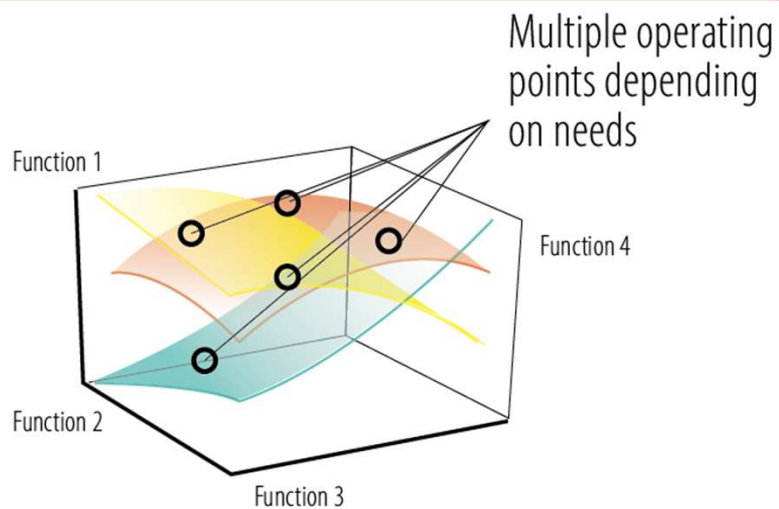
- CE Continental European market
- GB UK market
- IR Rep. & Northern Ireland market
- NORD Nordic market
- EBGL EU Electricity Balancing Guideline (2017/2195)
- IGCC International Grid Control Cooperation
- PICASSO Platform for International Coordination of Automated Frequency Restoration and Stable System Operation (aFRR)
- MARI Manually Activated Reserves Initiative (mFRR)
- TERRE Trans European Replacement Reserves Exchange (TRR)

CAPABILITY OF ANCILLARY SERVICE

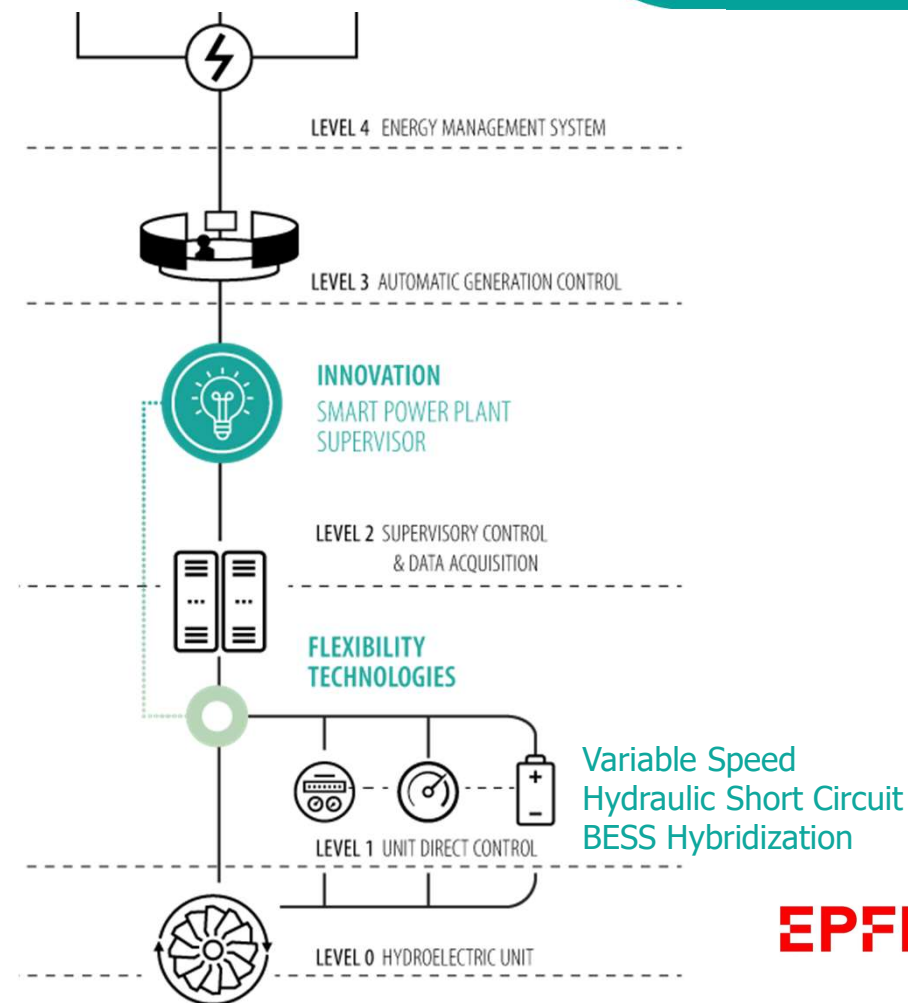
- Not currently capable of providing the service
- Capable, but could be enhanced
- Currently capable of providing the service

SMART POWER PLANT SUPERVISOR (SPPS)

Standard Communication bus



Digitilisation is one clue to extended services



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 innovative systems into a very high head pumped storage plant, with simultaneous use of 140/150 MW fixed-speed pumps and 150 MW turbines in hydraulic short circuit.
- Using smart supervisor control optimisation, a number of pumps will be operated to ensure net power consumption from the grid, while in parallel a Pelton turbine will regulate the load for frequency support and flexibility service.

Automatic Frequency Restoration Reserve

WP 6

Demonstrator
(Grand Maison)
Lead: EDF (GE)



Hes·so
Haute Ecole Spécialisée
de Suisse occidentale

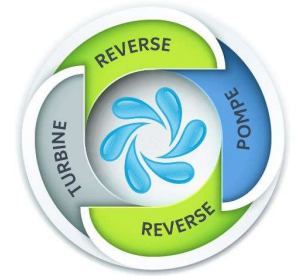
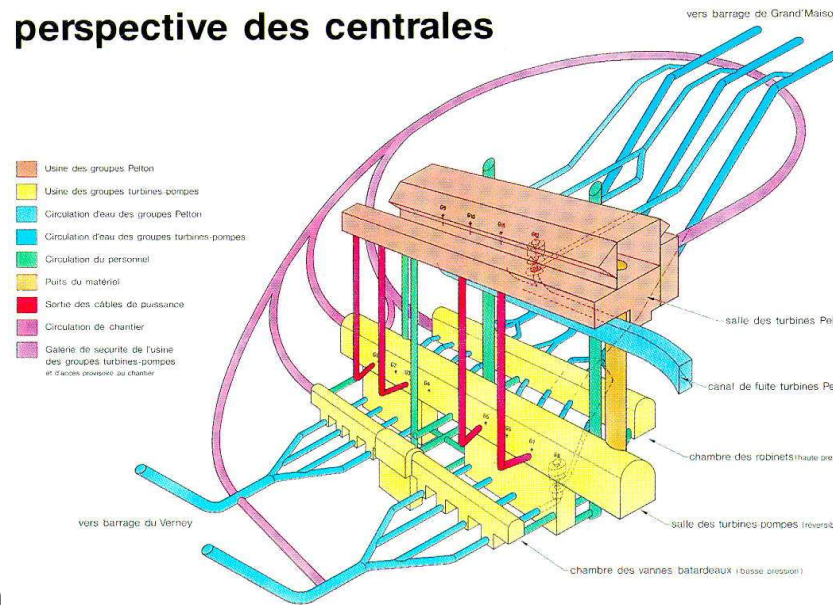


EPFL

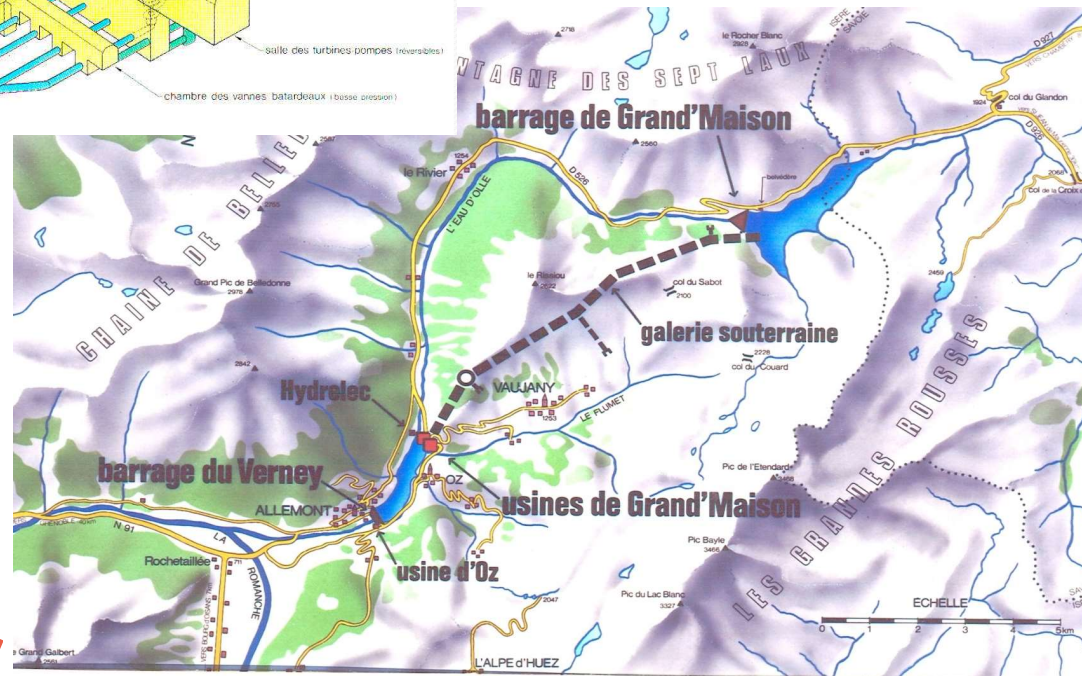


DEMONSTRATOR REVERSE

perspective des centrales

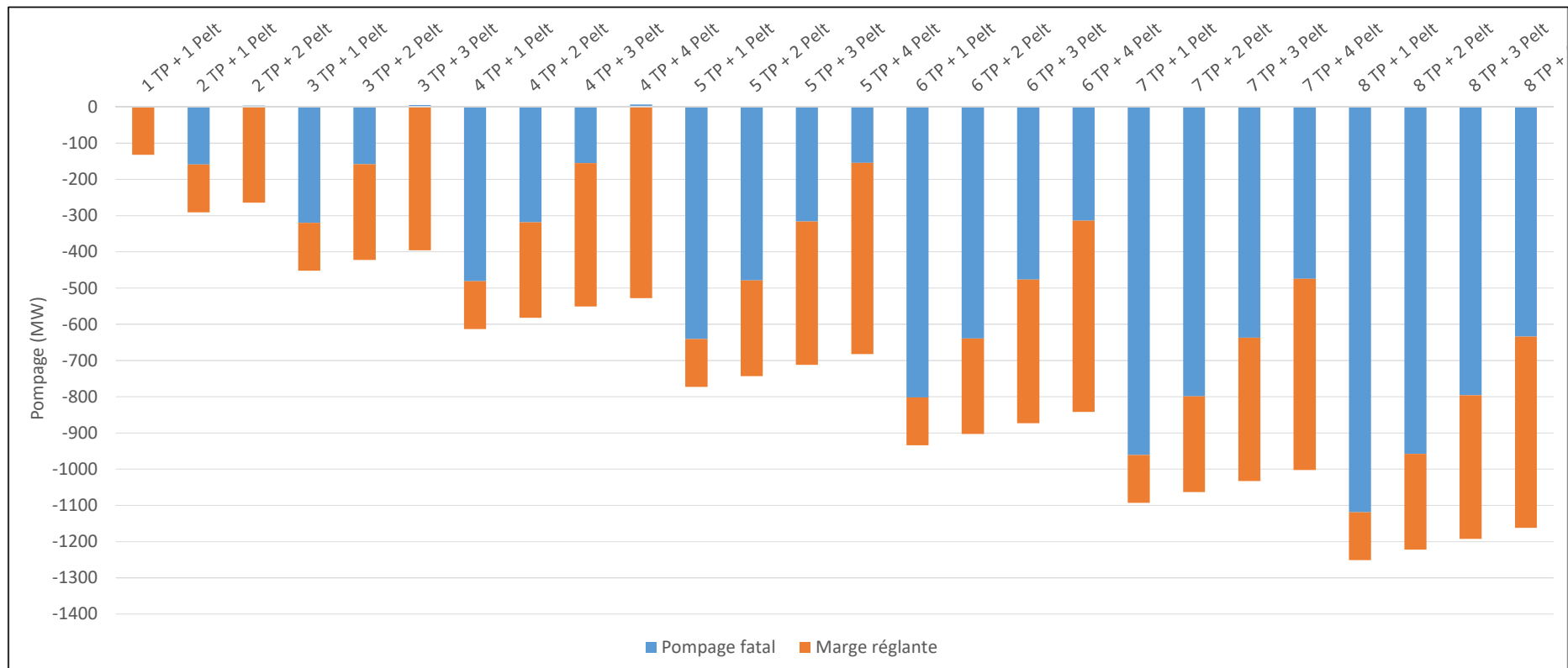
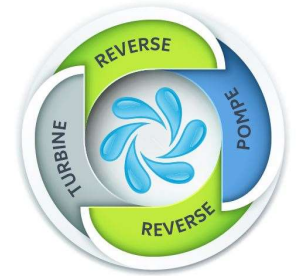


- Grand Maison PSP ; EDF; France
- Grand Maison PSP feature:
 - Largest PSP in Europe, 1985
 - 1800MW capacity with 900m head
 - 4 Regulating Pelton (new runners in progress), 150MW to 170MW
 - 8 Non regulating Pump Turbine 140/150MW
 - 15 m³/s per unit
 - 2 reservoir : 150Mm³ and 15Mm³



DEMONSTRATOR REVERSE

- REVERSE operating points
 - From 0 to -1200MW
 - Up to 500MW regulating power available within seconds
 - Low Carbon regulating Power (100 000 tons CO² saving/year)



DEMONSTRATOR

VOGELGRÜN FRANCE



x4



39MW



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, and in XFLEX HYDRO one unit will be equipped with a battery hybrid. The battery system will add energy storage to share response capability with the hydraulic unit, and use a master control to optimise flexibility services and wear and tear.

Key Objectives:

- Hybridise the turbine unit with a battery of suitable energy capacity and power converter rating, to improve fast and dynamic frequency response of the combined system.
- Significantly reduce turbine wear and tear, and quantify it.
- Evaluate the possibility of upgrading the 39 MW fixed-speed, double-regulated Kaplan turbine unit – with an enhanced variable speed, single-regulated propeller unit.

Frequency Containment Reserve

WP 9

Demonstrator
(Vogelgrun)

Lead: EDF (Andritz)



DEMONSTRATOR

VOGELGRÜN FRANCE



x4



39MW



RUN-OF-RIVER

1959



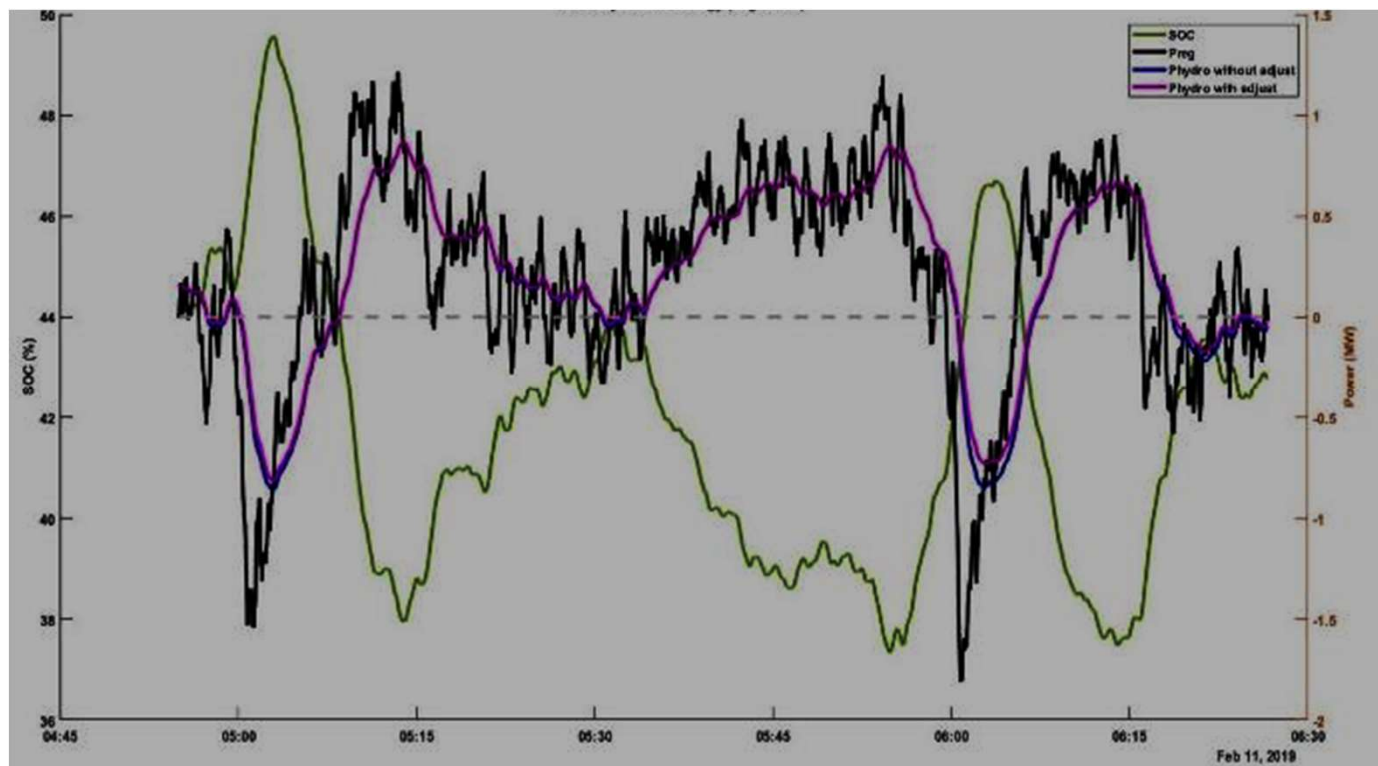
BATTERY/
TURBINE
HYBRID
TECHNOLOGY

Battery Hybridization

WP 9

Demonstrator
(Vogelgrun)

Lead: EDF (Andritz)



DEMONSTRATOR

VOGELGRÜN FRANCE



x4



39MW



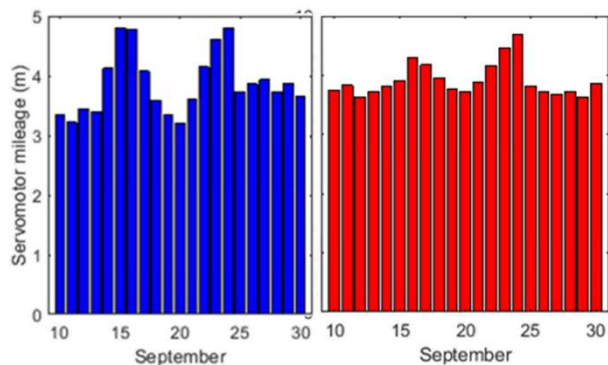
RUN-OF-RIVER

1959



BATTERY/
TURBINE
HYBRID
TECHNOLOGY

Control mileage reduction

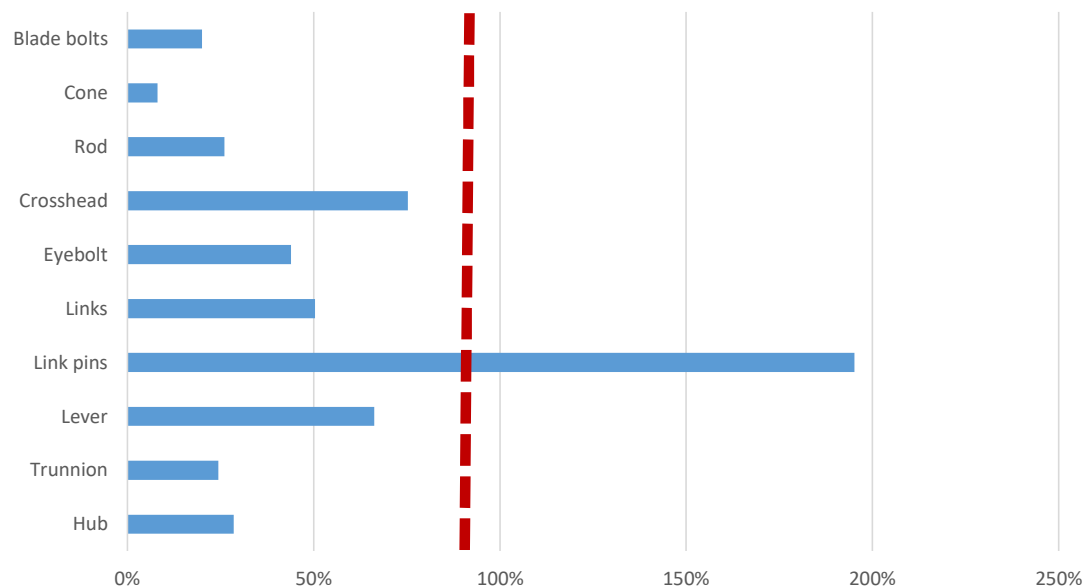


Runner Blades and Guide Vanes mileage > 300 full strokes in a month!

WP 9

Demonstrator
(Vogelgrun)
Lead: EDF (Andritz)

Actual / Allowable stress amplitude



KPIs MATRIX

- Extended operation range
- Fast Start and Stop
- Fast Ramp-up/Ramp-down
- Fast turbine-pump / pump-turbine transition
- Optimised maintenance intervals
- Extended reliability
- Increased weighted efficiency
- Asset health maximization
- Digitalisation

		KPIs			
Demonstrators	●	●			
		●	◐		
	●	◐	◐	●	
	●				
		Technologies			

XFLEX HYDRO

**Webinar on the 12th of July
to report on both the ancillary services and
KPI matrices.**

**Next site visit of Alqueva PSP (EDP) on the
21st of July.**

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