Webinar: Pumped Storage Hydropower: Opportunities and Challenges in SAARC Region

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PSH Sustainability and Challenges in the European Union

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D.2. Ocean and Water

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The European Commission, DG JRC, Ocean and Water unit

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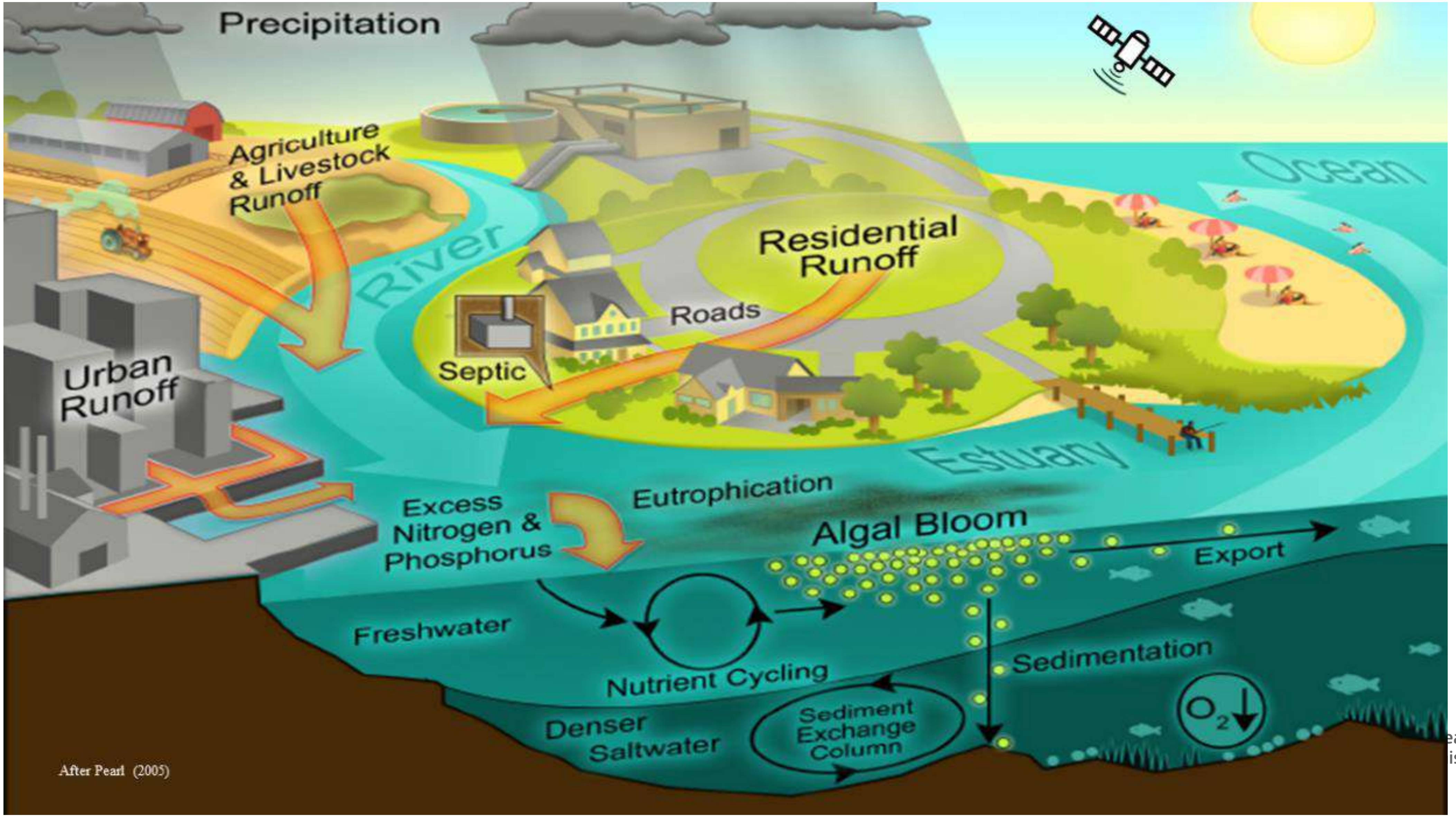
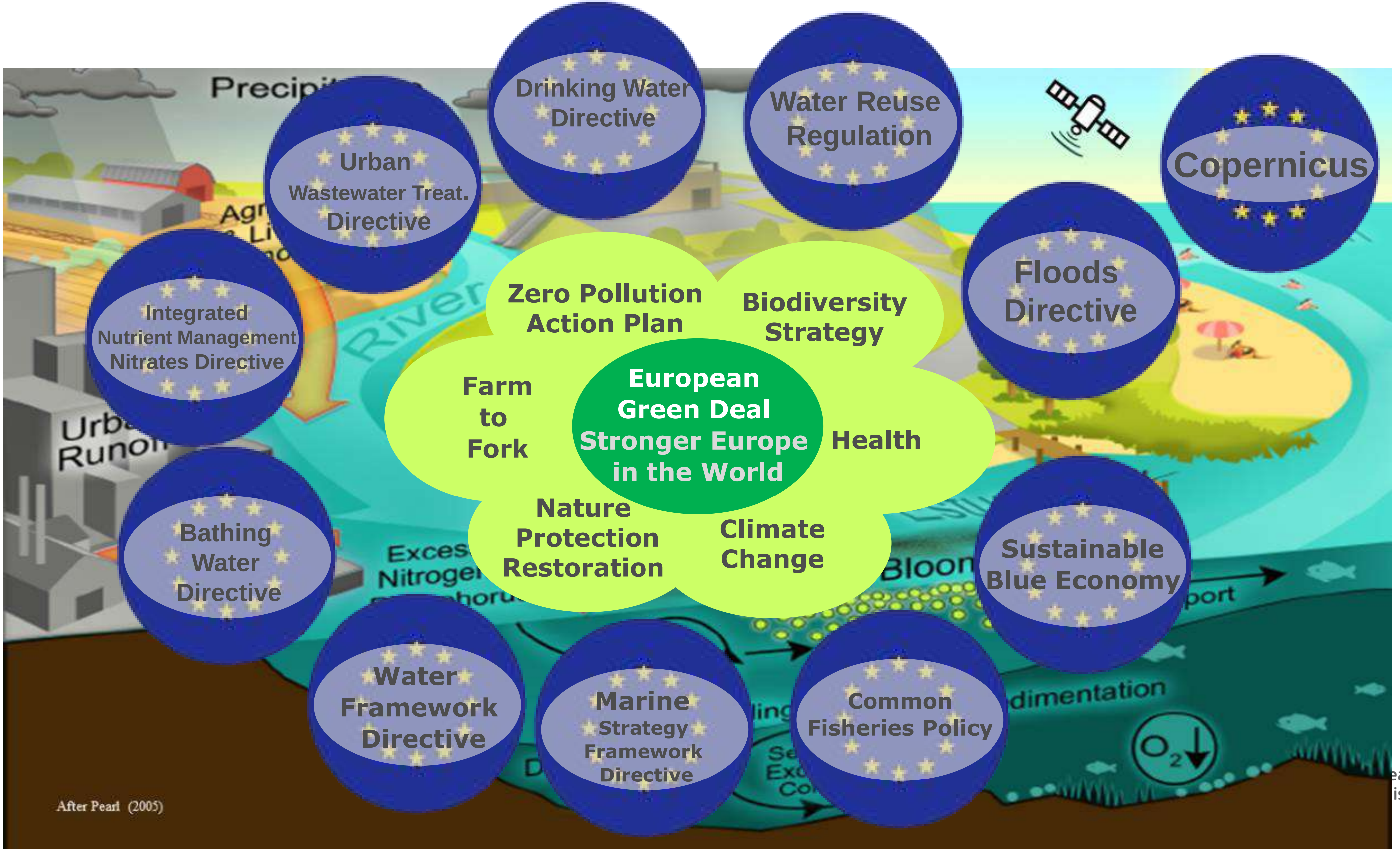
JRC Ocean and Water

Holistic and integrated support: freshwater - coast - sea



The EU Water Acquis (extended)



Sustainability in hydropower

Hydropower is at the center of a significant debate due to its opportunities as a renewable energy source, as well as its challenges and impacts

Hydropower debate: benefits vs impacts

- Renewable energy, energy storage, flexibility
- Water management, flood control and water storage (e.g., for irrigation)
- Tourism
- Market development
- Job opportunities

- Fish injury
- Sedimentation
- Fragmentation
- Hydropeaking
- Flooding upstream
- Ecosystem alterations

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Hydropower and policies with different targets

Water Framework Directive: Hydropower as a source of impact

Renewable Energy Directive, REPowerEU: Hydropower as a clean energy technology

Flood Directive: Reservoirs can be a dangerous interference, but reservoirs can mitigate droughts and can provide water storage

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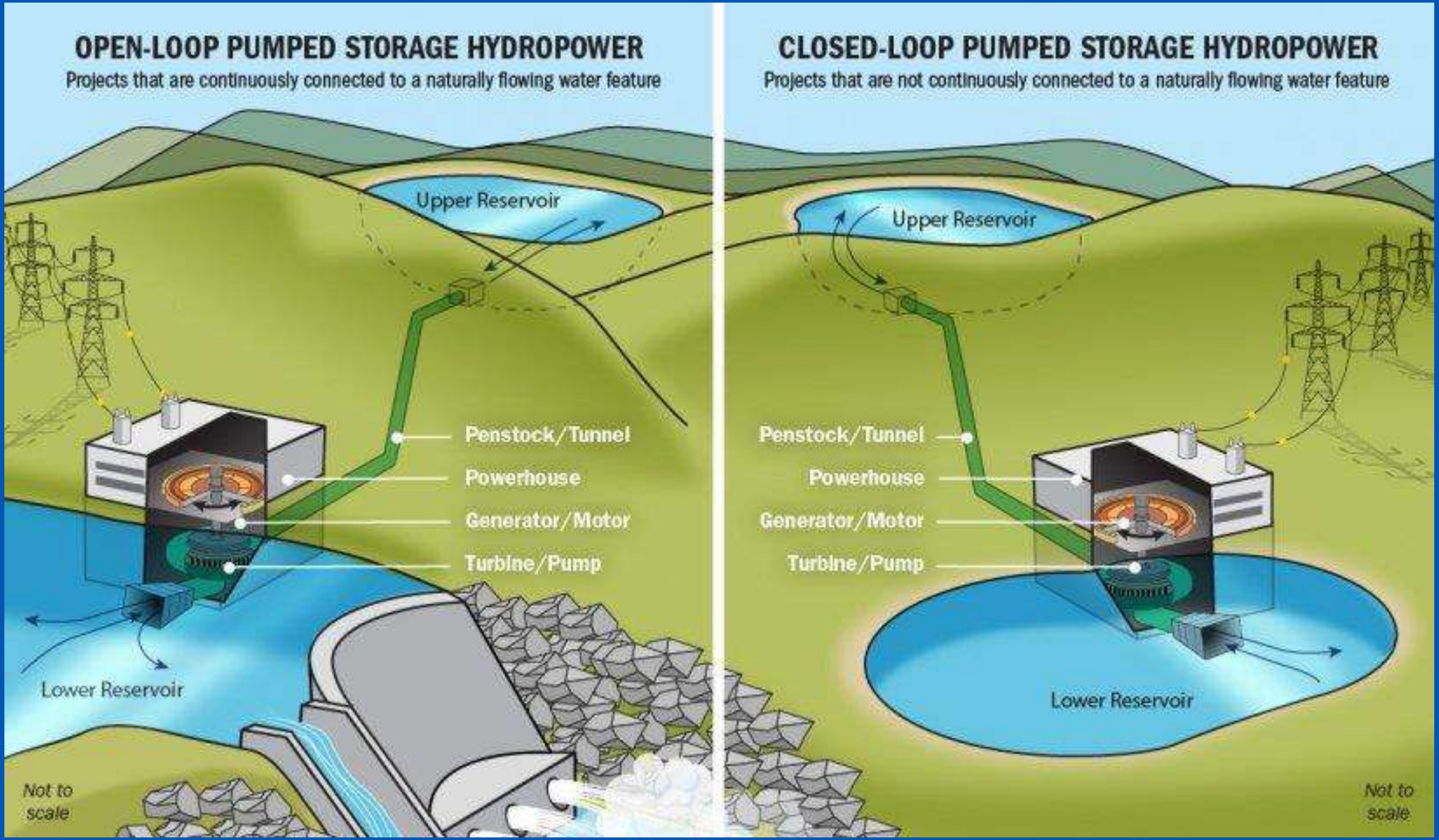
Conflicts can be overcome by sustainable hydropower

Sustainable hydropower needs to achieve a good balance between electricity generation, social benefits and impacts on the ecosystem and biodiversity, developing mitigation solutions and innovative technologies.

Pumped-storage hydropower

Pumped-storage hydropower plants



The vertical distance between the two reservoirs is called head

Energy storage in RSHP (reservoir-type hydropower) and PSH is the largest source of energy storage today and is the only mature technology for long duration energy storage (IEA, 2023b, World Bank, 2024). Globally, reservoir hydropower has a storage capacity of about 1500 TWh, which is about 170 times more than the global fleet of PSH plants and almost 2200 times more than the Li-Ion battery capacity of both stationary and automotive applications (IEA 2021). Excluding reservoir hydropower, more than 90% of the remaining energy storage in the world is in PSH (IHA, 2024)

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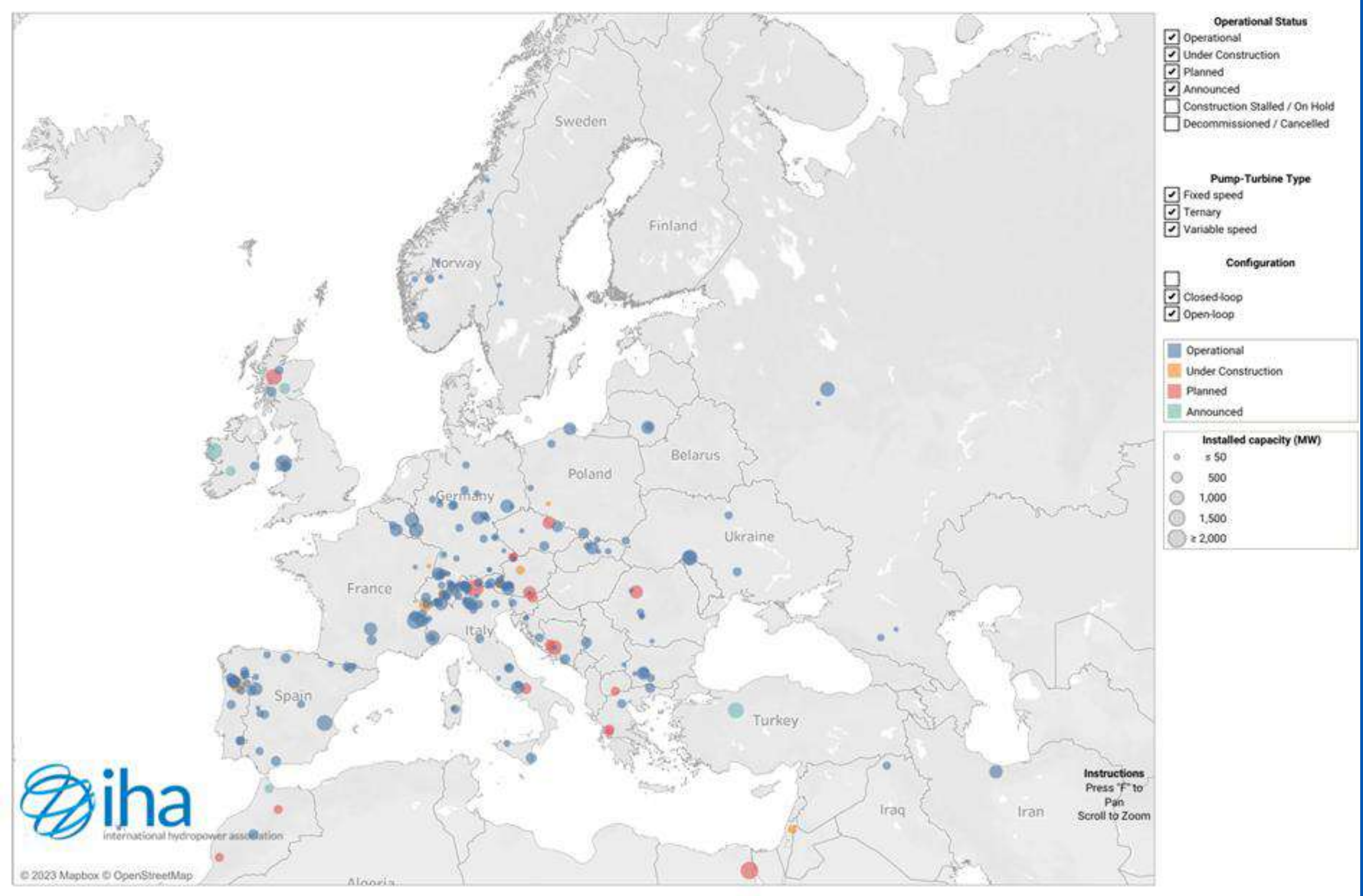
PSH in the EU



Installed power in the EU: 46 GW, more than a quarter of the global installed capacity (IHA, EUROSTAT), 1200 GWh of technical energy storage

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Sustainable Water&Energy storage, and PSH, solutions:
Focus on the EU

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How to develop new PSH, and increase energy storage capacity, including sustainable options without damming rivers?

Some options in the following slides.

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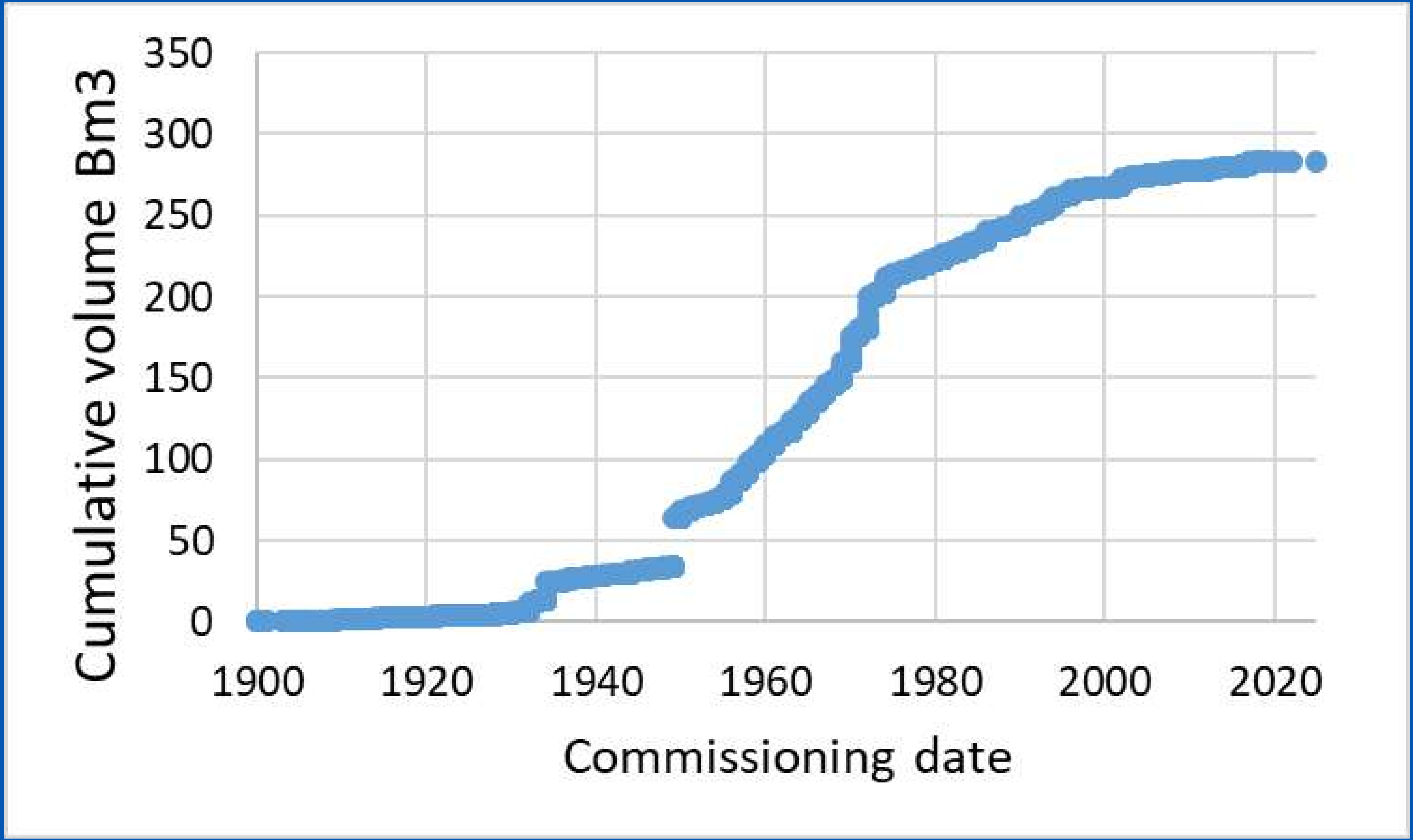
Age of large dams in the EU (ICOLD, 2023)



Modernisation and flexibility increase, using existing hydropower dams

Increasing generation

+40 TWh/y of annual energy generation potential (Quaranta et al., 2021) (>+11%) by:

- *Digitalization of the operation.*
- *Replacement of electro-mechanical equipment*.
- *Waterways and penstocks*.

Increasing flexibility

- *As above, but especially:*
- *Variable speed turbines*
- *Short-circuit operation*
- *Optimisation at part-load operation*
  → X-FLEX Hydro

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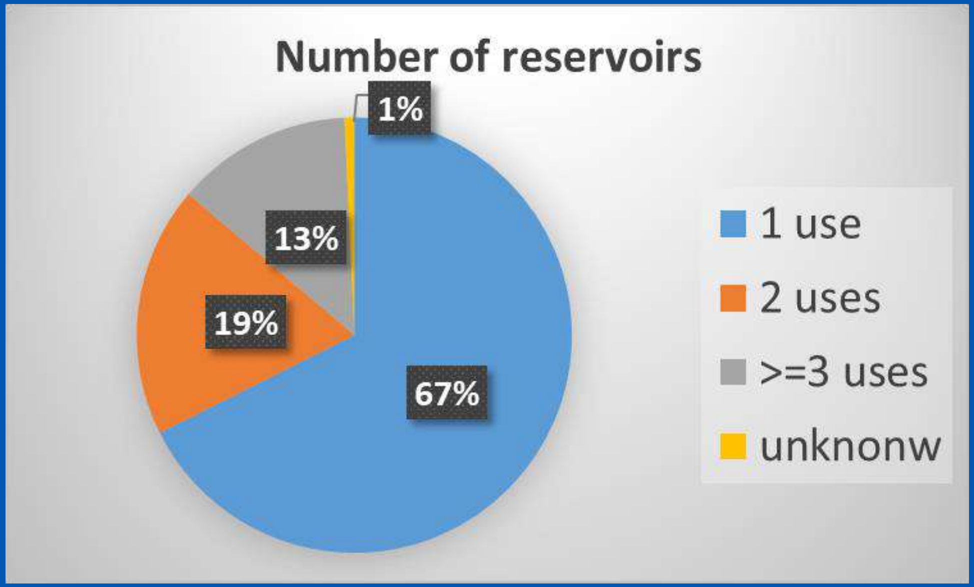
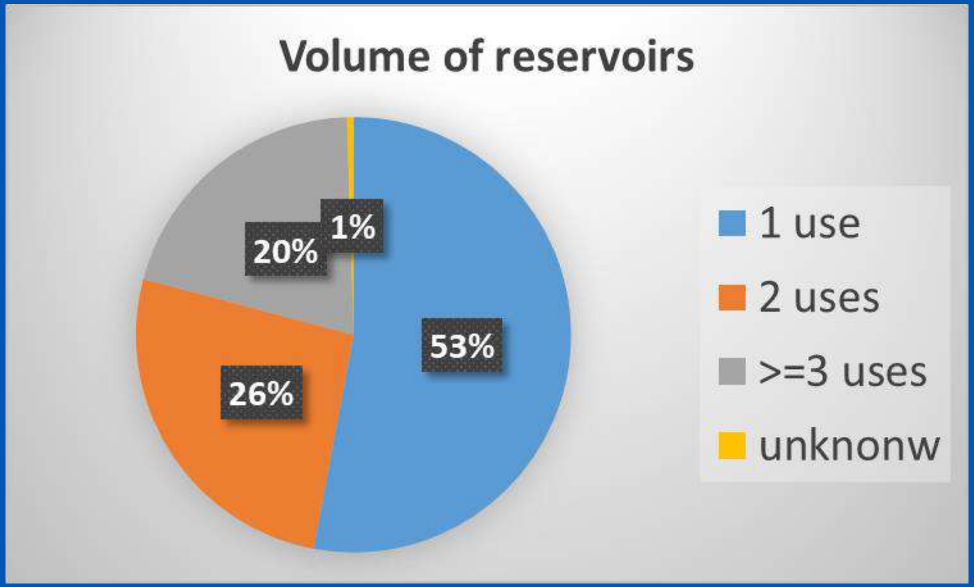
Hybridisation with Floating Photovoltaics (FPV) and batteries

Single and multi-purpose reservoirs in the EU (+CH)

Ref: ICOLD





Total volume is 280 billion m3

De-Sedimentation

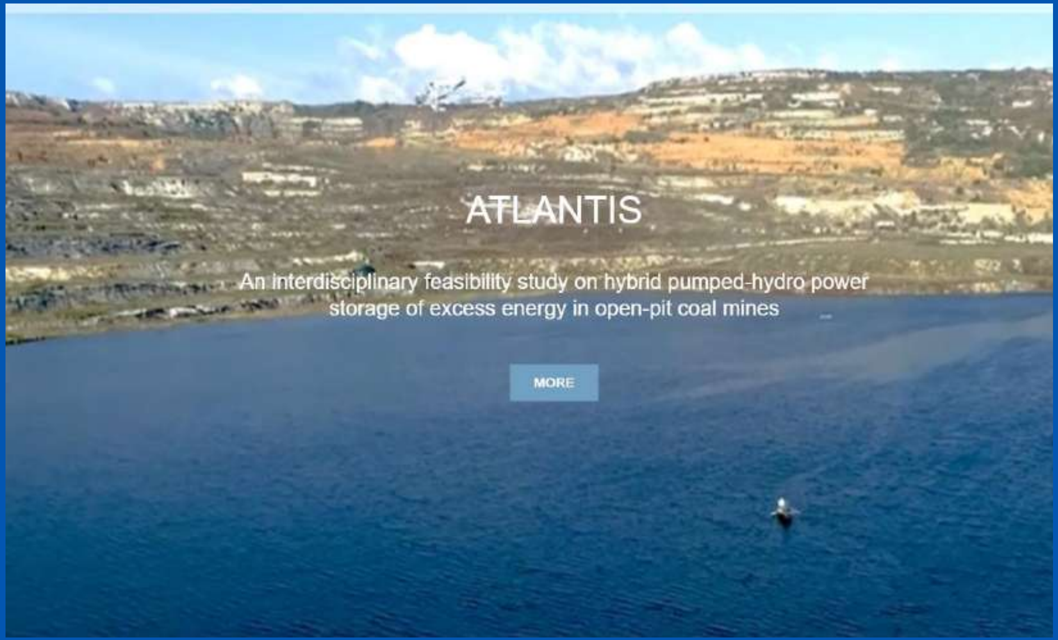
Annual sediment inflow into the EU's reservoirs: approx. 0.7% of the reservoirs' volume, but mitigation measures (e.g., bypasses, flushing) minimize the sediment accumulation in the reservoir.

Solutions: dredging, flushing and prevention measures (greening to avoid soil erosion, lateral bypass canals).

Potential cost of all sediments removal ranging from 5 to 8 Billion € annually.

https://www.sciencedirect.com/science/article/pii/S095965262304341X

PSH in abandoned mines



Weber et al. (2024).
+7 TWh in the EU (4 TWh the most economic sites)

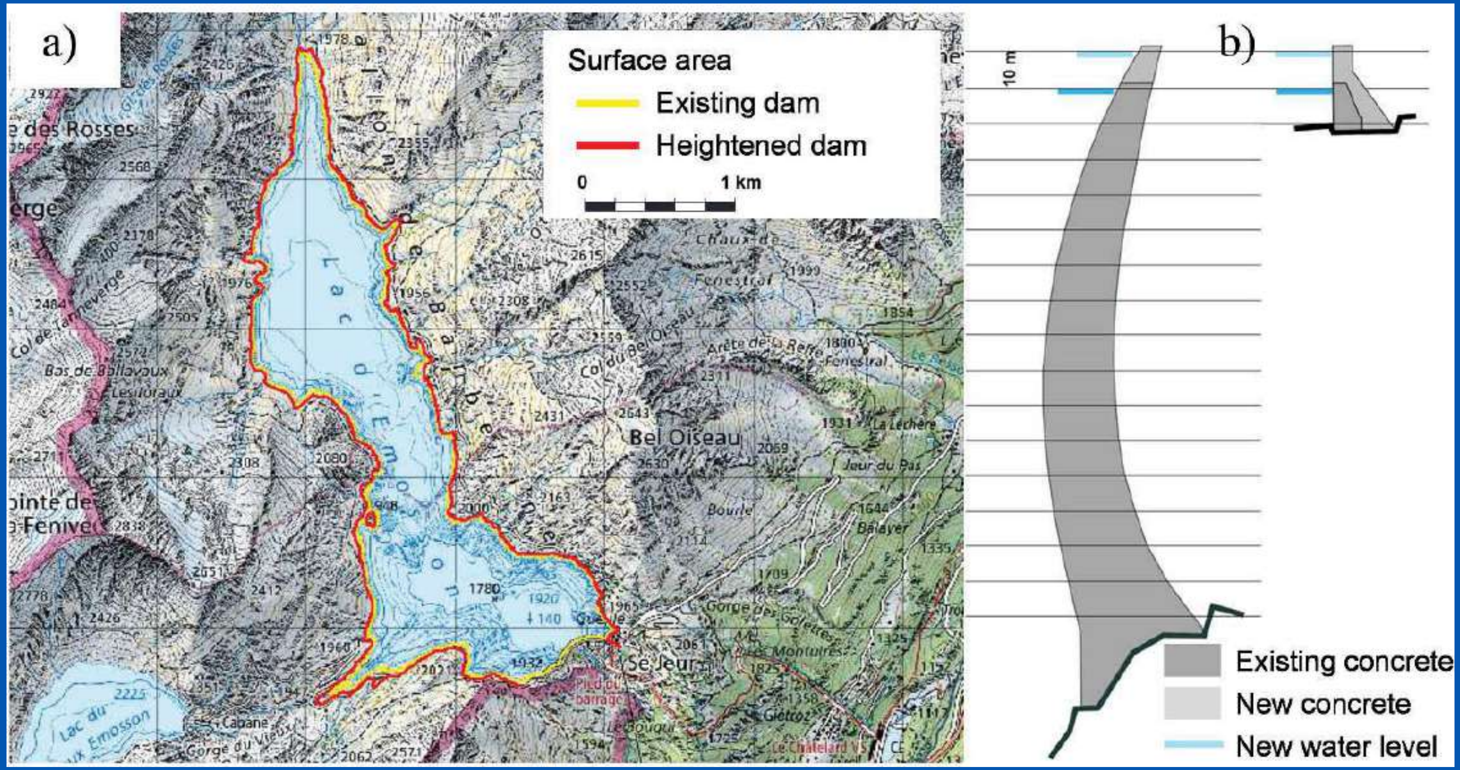
https://www.sciencedirect.com/science/article/pii/S0960148124001782

Reservoir interconnection

Gimeno-Gutiérrez and Lacal-Arántegui (2015)

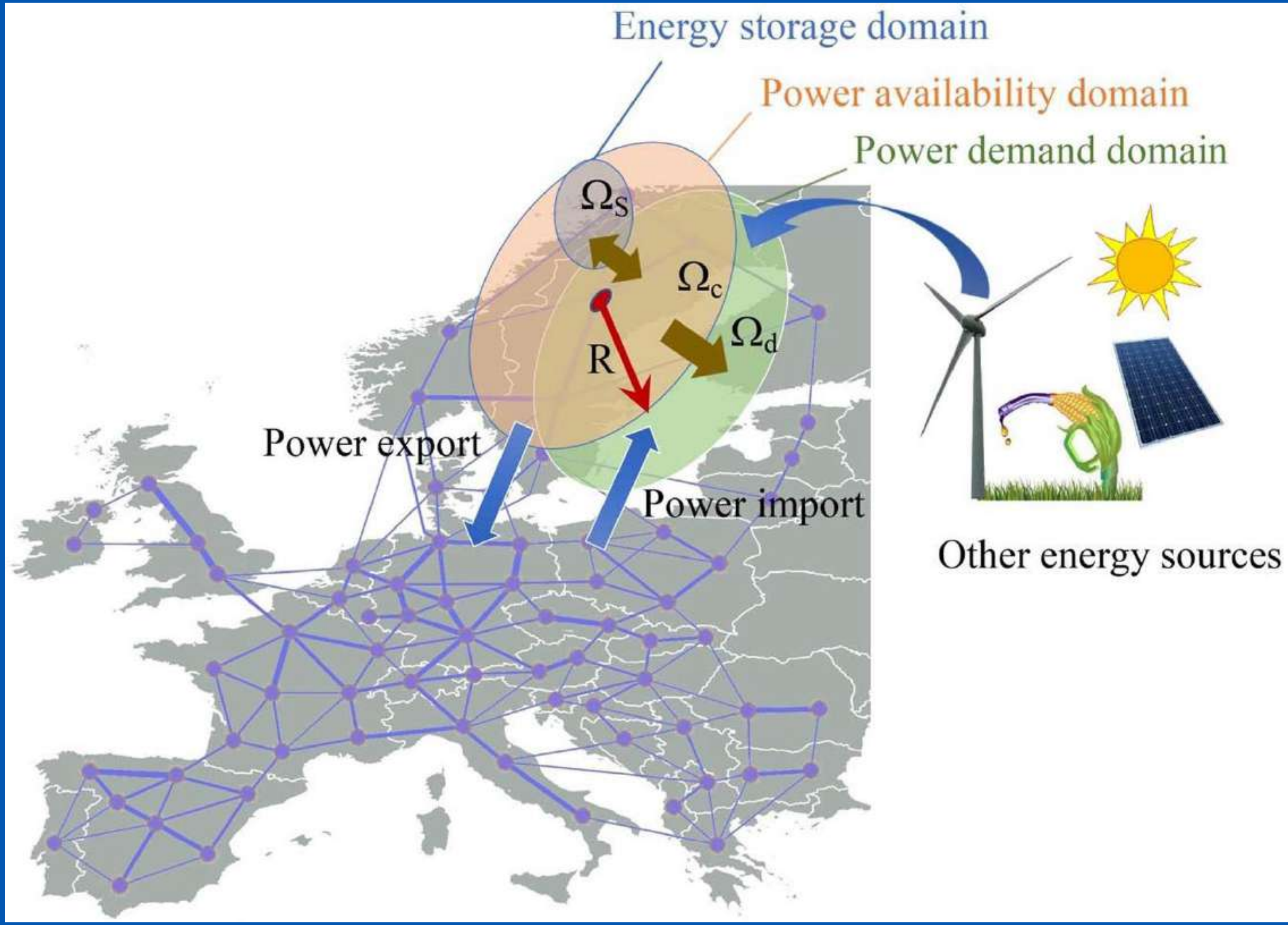
Potential (GWh)	20 km	10 km	5 km	3km	2 km	1 km
Theoretical	14238	3593	886	319	76	5

Dam heightening



Fauriel et al. (2023).
+30% (= +2 TWh) in Switzerland

Grid expansion and continental interconnection



Worman et al. (2024). 200 TWh reduction of energy storage demand over 5 years

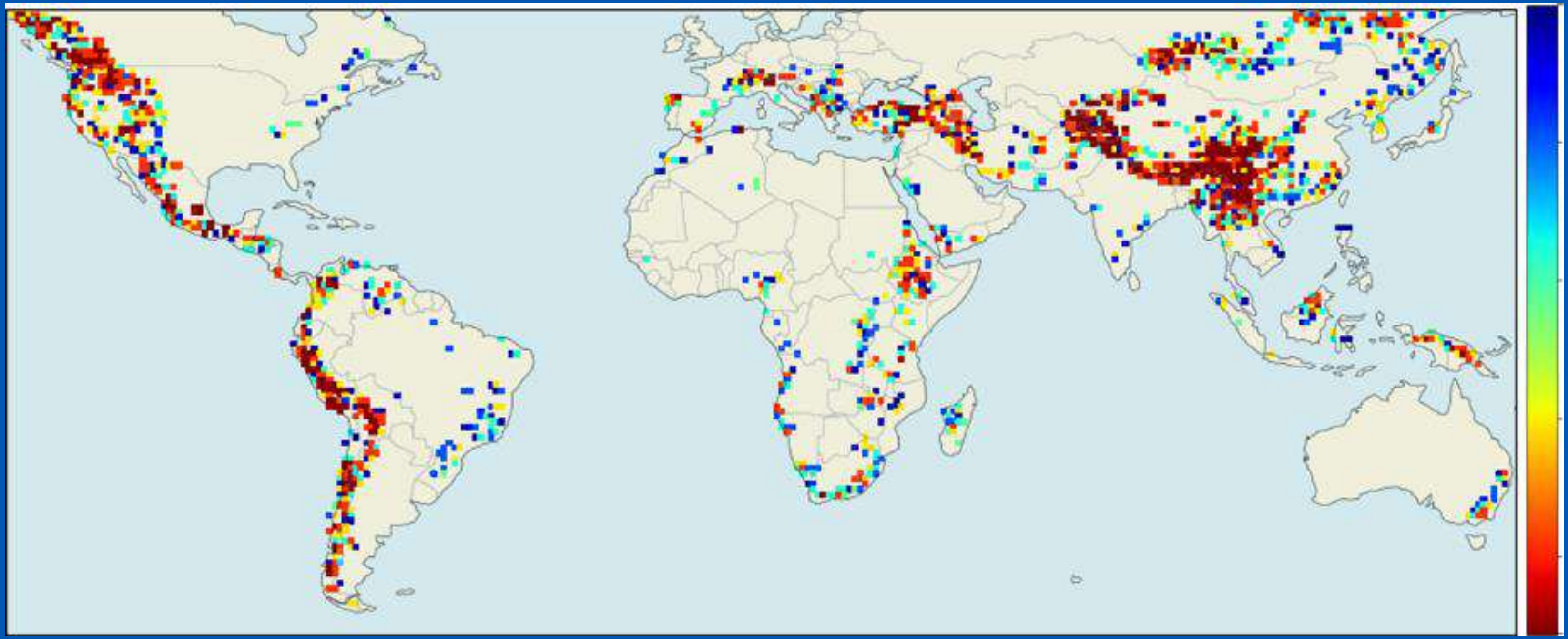
New green-field PSH

Some options in the following slides.

Potential of closed-loop PSHs

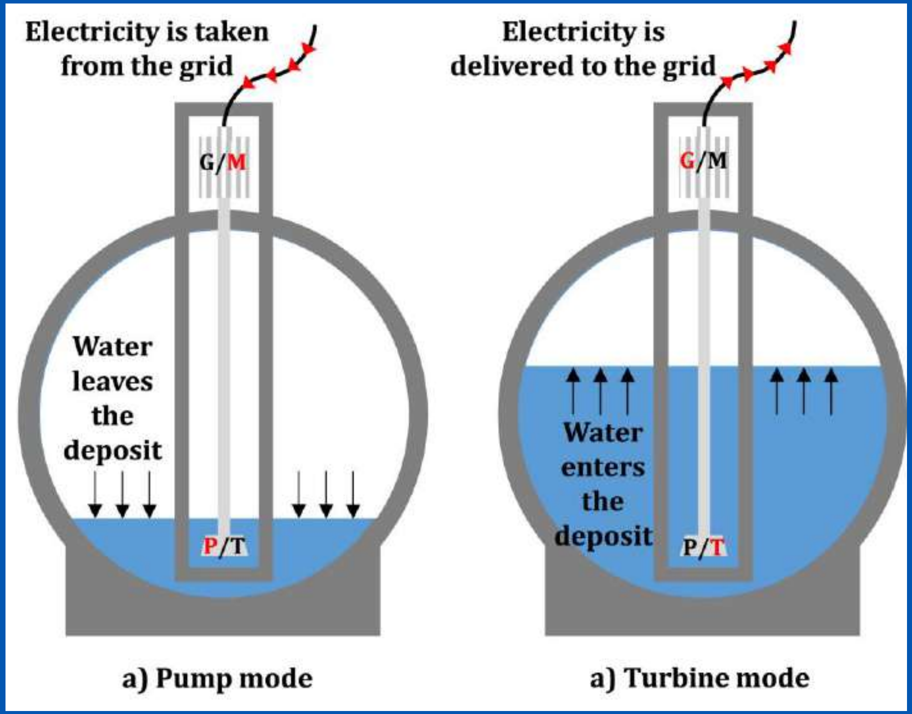
Stocks et al. (2021): 300 TWh (the cheapest sites are 25 TWh)

Potential for open-loop seasonal PSHs



Hunt et al. (2020).
The cheapest sites were found to represent 10-14 TWh

Ocean energy storage



On the sea bed

PSH using the ocean

Sustainable hydropower potential

How to develop new hydropower in a sustainable way?

Some options in the following slides.

Modernisation/Refurbishment

+40 TWh/y -> + 11%

References: Quaranta et al., (2021), and Quaranta and Muntean, (2023)

- *Digitalization of the operation.*
- *Replacement of electro-mechanical equipment*.
- *Waterways and penstocks*.

Improving:

- generation, flexibility
- Sustainability and safety
- Resilience to climate changes
- Water resources management

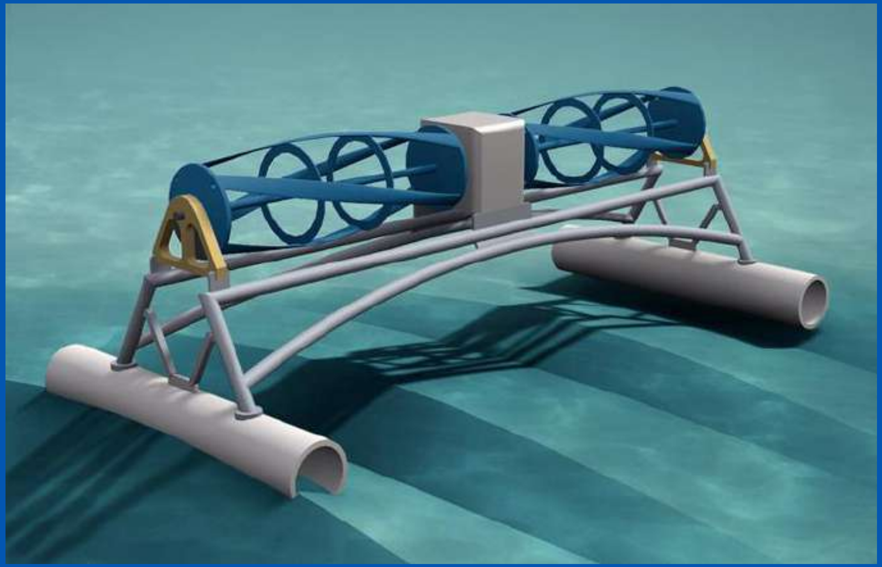
Hydropower potential in historic low head sites (e.g. water mills

+ 8 TWh -> +2.5%
Reference: Quaranta et al., (2022)

Hydrokinetic turbines

+3 TWh/y -> + 1%

References: Quaranta et al., (2022), Quaranta and Muntean, (2023)



Hydropower in WDNs and WWTPs

+3.1 TWh/y->0.8%

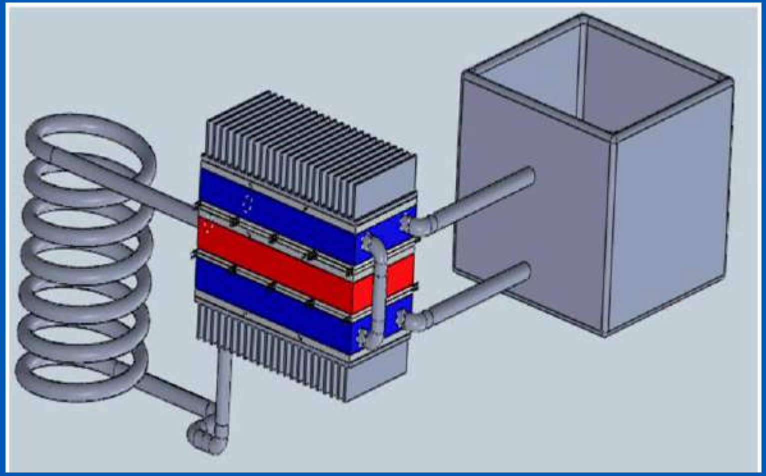
Reference: Quaranta et al., (2022)

Water Distribution Network (WDN), Wastewater Treatment Plant (WWTP)

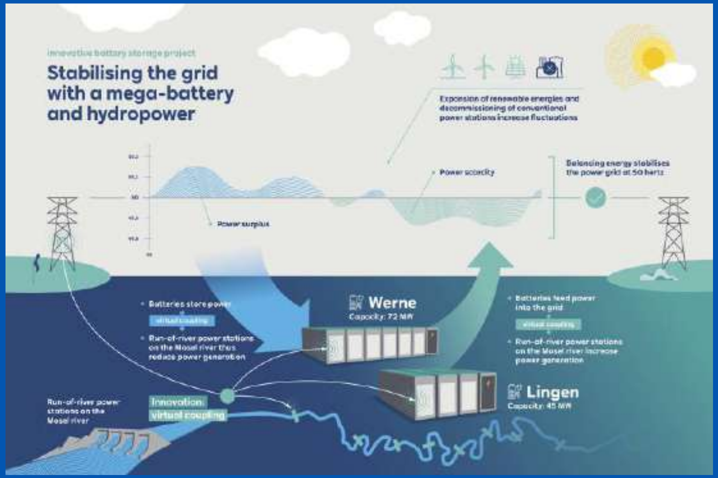
Hydropower and hybridization with other energy technologies

Photovoltaics

Wind



Heat extraction



Batteries

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Key personal references

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Thank you

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