Pumped Hydropower Storage: challenges and research developments

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Workshop on Long Duration Energy Storage 2.0

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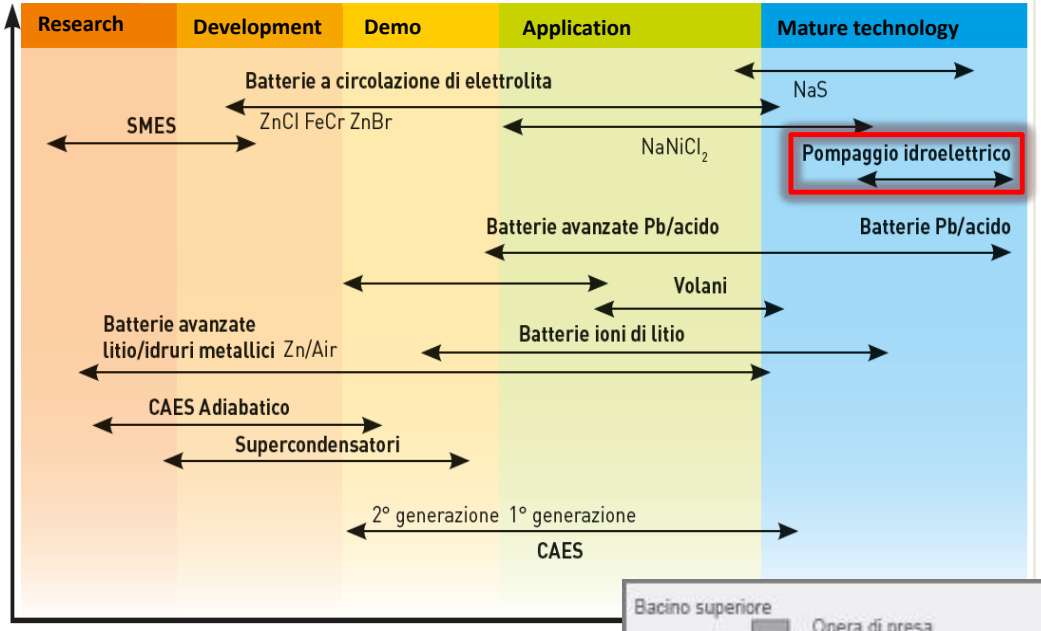
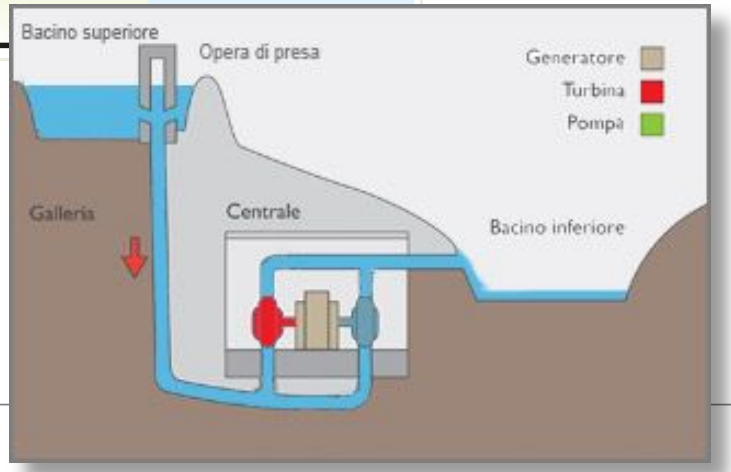
Present situation on storage technologies and pumped hydro



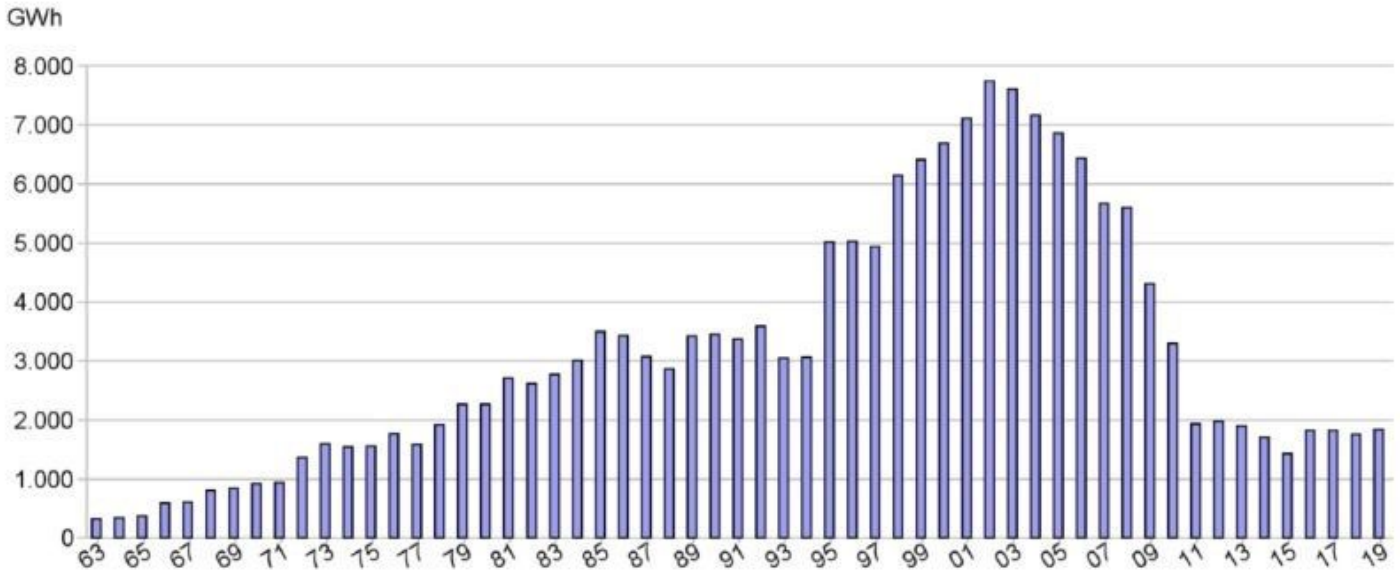


Available main pumped hydro plants (about 7.6 GW installed power)

Pumped hydro challenges

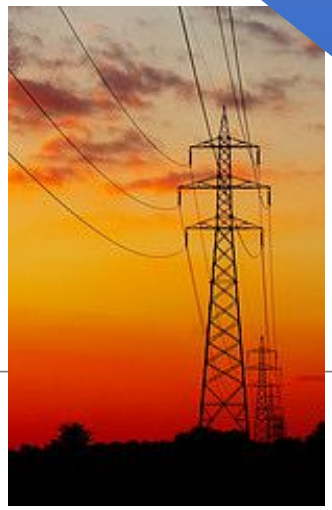
Since 2000, despite a slight increase in the power of the pumped plants installed (**today 7.6 GW, +5% compared to 2000**), there has been a **reduction** in their production, **in contrast** to what occurs in other European countries (Spain, Germany, France, Austria, Great Britain).

Terna Gross electricity production for pumping



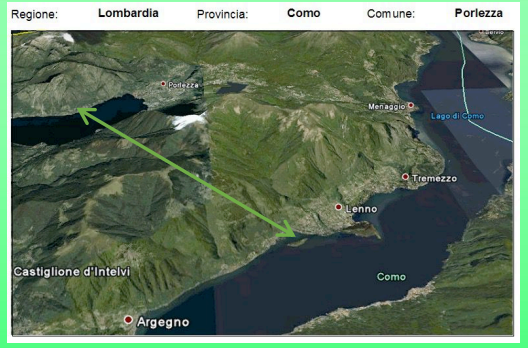
Integration of Non-Programmable Renewable Energy Sources (NPRES)

- It is possible to **accumulate energy in periods of high NPRES** production to re-enter the grid in periods of low production.
- In this way it is possible to **obtain an overall RES + storage generation profile**.
- In areas with a high development of RES, **the grid may not be "robust"** enough to evacuate all the power generated.



Type 1: Exploitation between two available lakes

Potential of 8 hypothesized hydro pumped plants:
1.5 GW of power
15 GWh storage

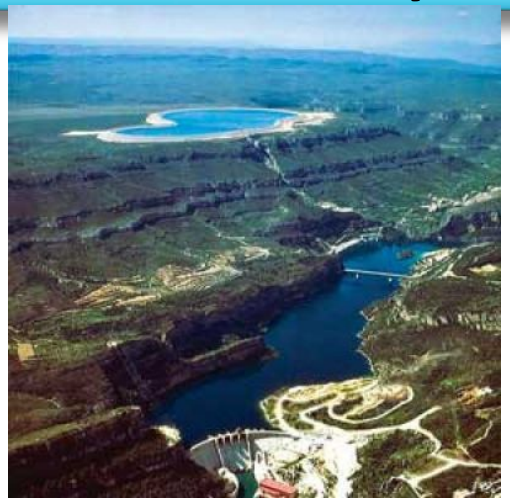


Exploitation between the lakes of Lugano and Como

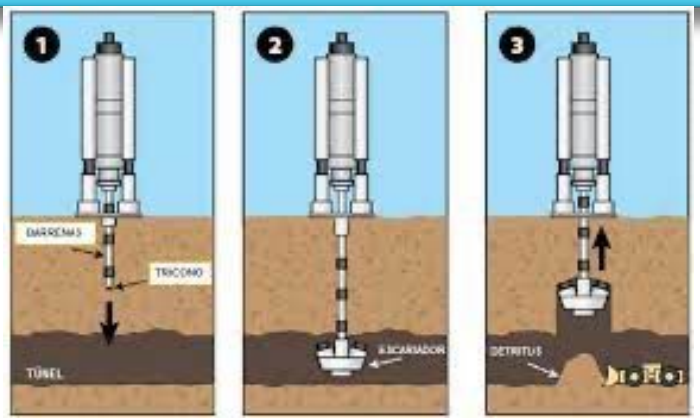
Nome impianto	Laghi				Superficie (km2)	Escursione massima giornaliera (m)	Volume movimentato giornaliero (m3)	Portata (m3/s)	Potenza pompe (MW)	Potenza Turbine (MW)
Porlezza	Lugano	9			48.7	0.3	14610000	338	295	213
	Como				145	0.1				
Valvestino	Valvestino				1.38	1	280000	32	169	122
	Garda				368					
Ledro	Ledro				2.19		0	25	179	129
	Garda				368					
Molveno	S.Massenza/Toblin			578	0.9	1		21		
	Molveno				3.27	0.28				
Lago Morto	Morto			884	0.126		000	38	401	
	Place Moulin				1.8					
Vico	Vico	17	508	347	12.93		3879000	90	3	89
	Bracciano		161		57.5					
Poma	Poma	15		425	1.63		489000	11	58	42
	Piana degli Albane				3.1	0.1				
Cucchinadorza	Omodeo				29.37	0.06		43		
	Cucchinadorza			557	1.17		1545000		219	158
	Gusana				2.52					
Totale									1837	**1326**

- ok from a technological point of view
- too many administrative and environmental barriers for using natural lakes.

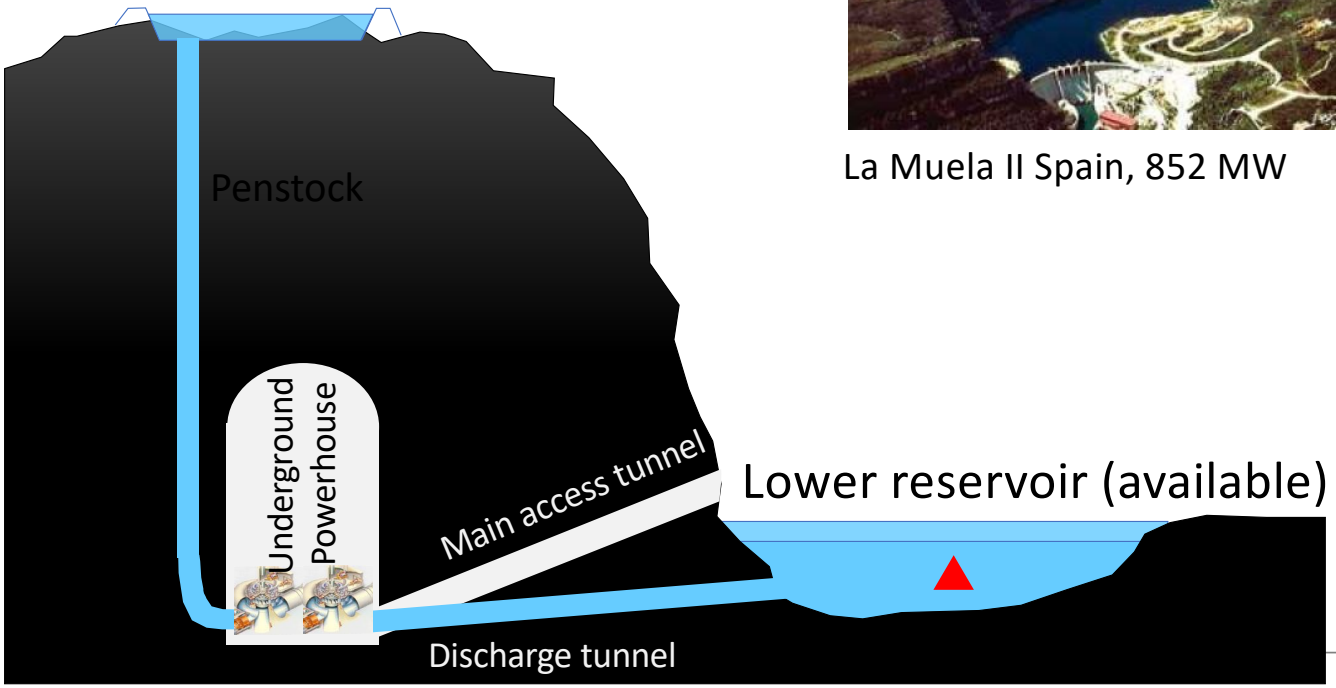
Type 2: Exploitation of an available reservoir by building a new one



La Muela II Spain, 852 MW



RBM Raise Boring Machine
(max diam. 7 m)



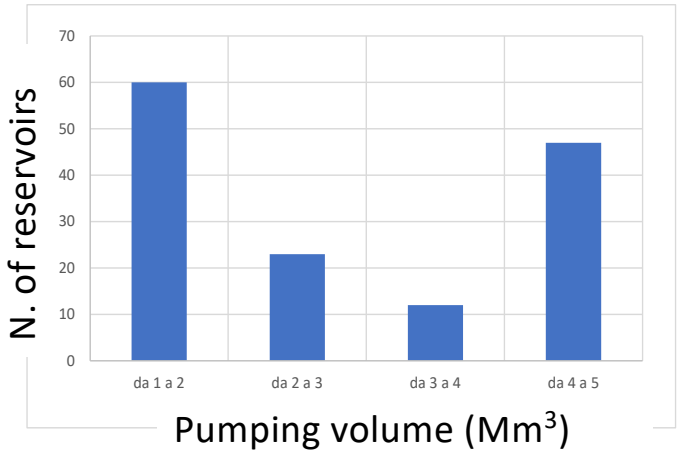
TBM Tunnel Boring Machine
(max diam. 15 m)

Characterization of available reservoirs

- Center point coordinates
- Plane coordinates WGS 84
- Total volume (Mm^3)
- Maximum reservoir level (m a.s.l.)
- Maximum surface (km^2)

Reservoirs suitable for pumping and maximum volume dedicated to pumping:

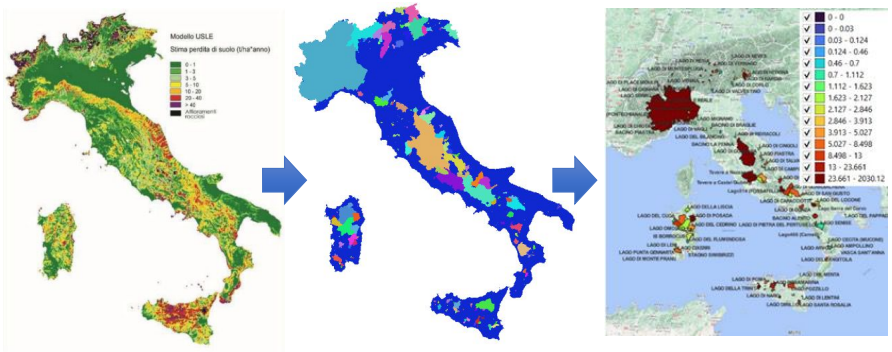
- 10% useful volume
- < 5.000.000 m^3
- >1.000.000 m^3

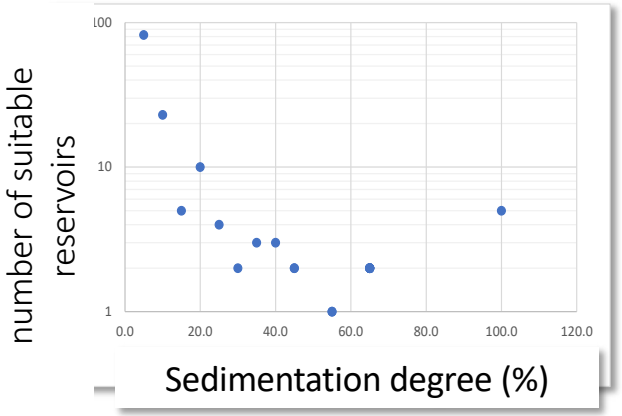


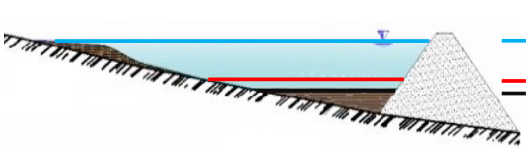
Over 140 Reservoirs suitable for pumping

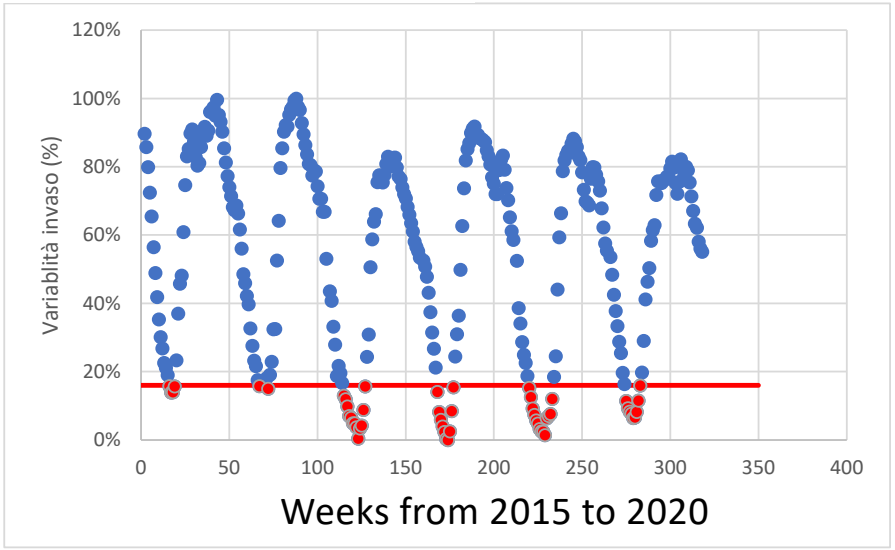
Correlation between the sedimentation degree and the usability for pumping

General method for the **characterization of future hydro pumped plants** considering the **incidence of the seasonal variation of the level**.









Example of variability of reservoirs and weeks with levels below 16%.

Where to build the new upper reservoirs?

Exploitation of an available reservoir by building a new one

Available reservoir

Searching boundary

EUAP 2011

SIC

Urbanized areas

Landslide risk high danger P3

Landslide risk very high danger P4

Heads less than 200 m

Area with slope less than 10%

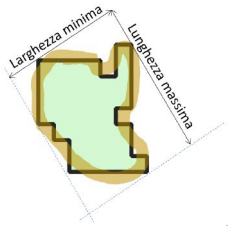
New reservoir suitable area

New reservoir volume:

< 5.000.000 m³

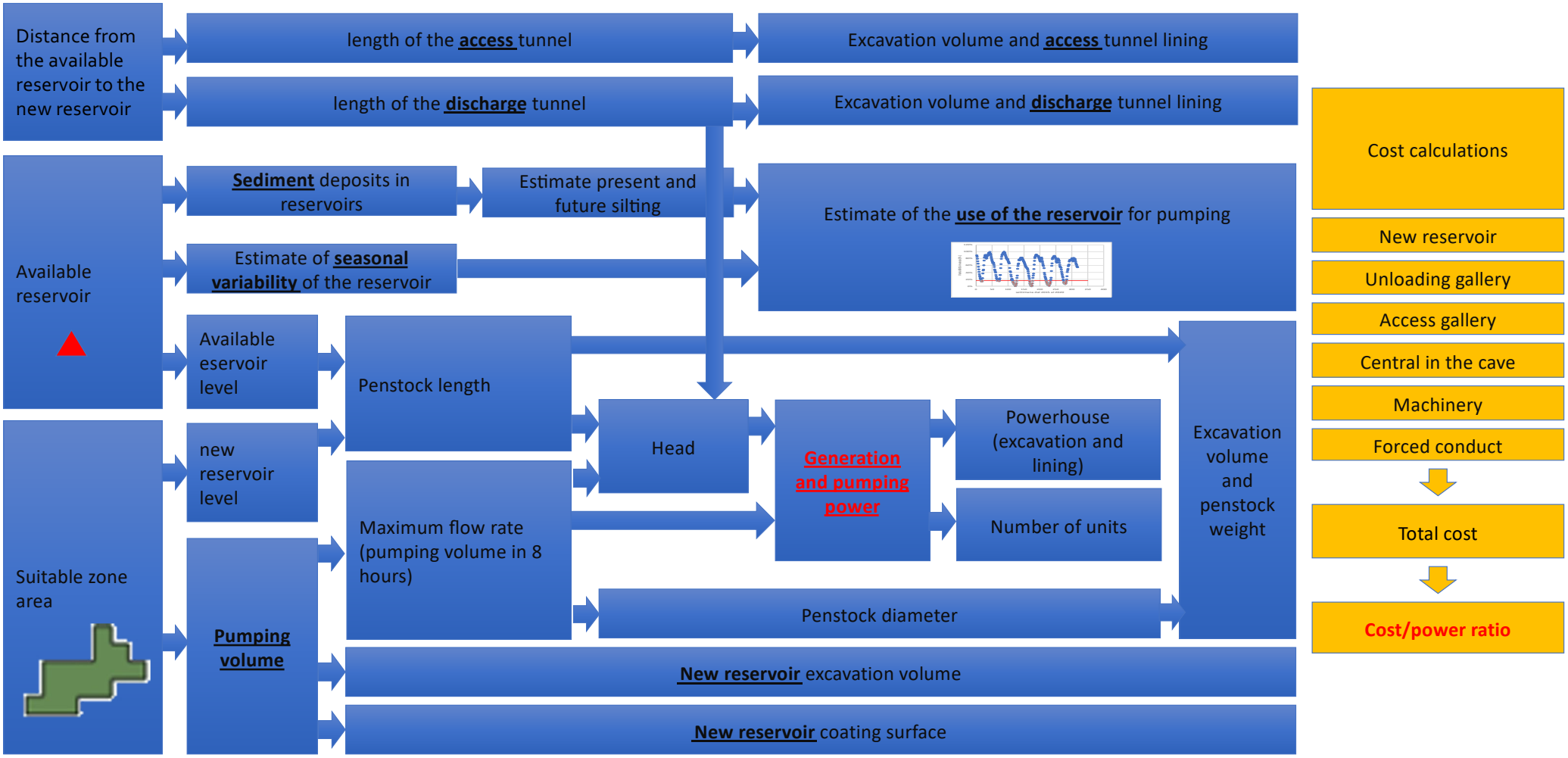
> 500.000 H/Lm³

H/L < 3

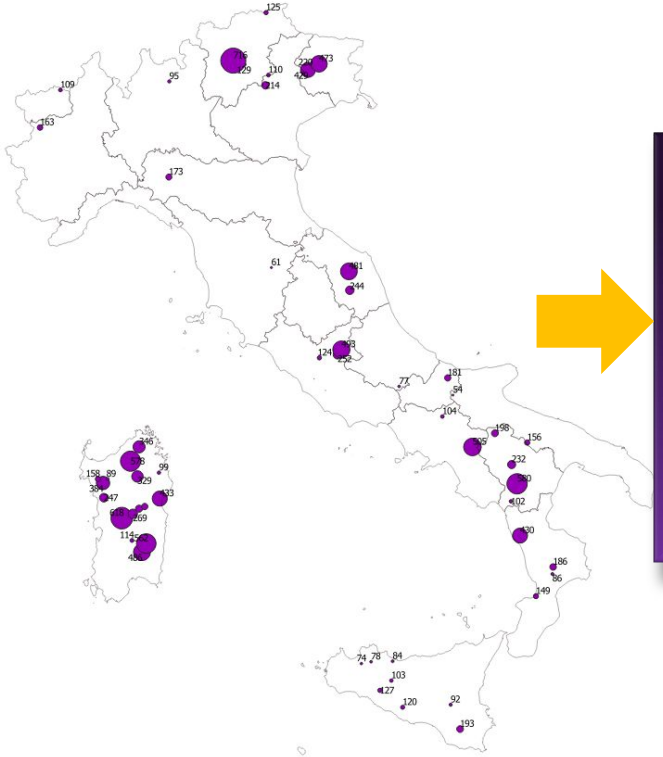


RSE Ricerc
Via R.

Sizing, characterization and costs of the potential pumped hydro plants

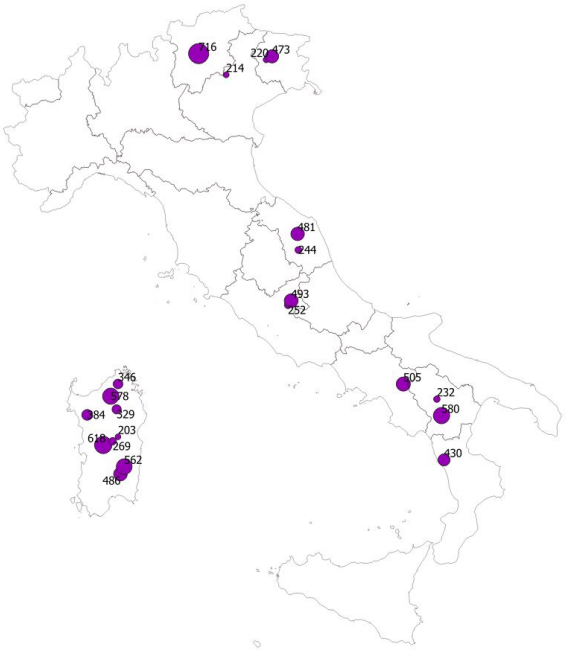


Suitable pumped plants



Filter
- Cost/Power ratio < 2 M€/MW
- Power greater than 200 MW

Pumped plants
- 21 plants 9 GW
- 80 GWh storage

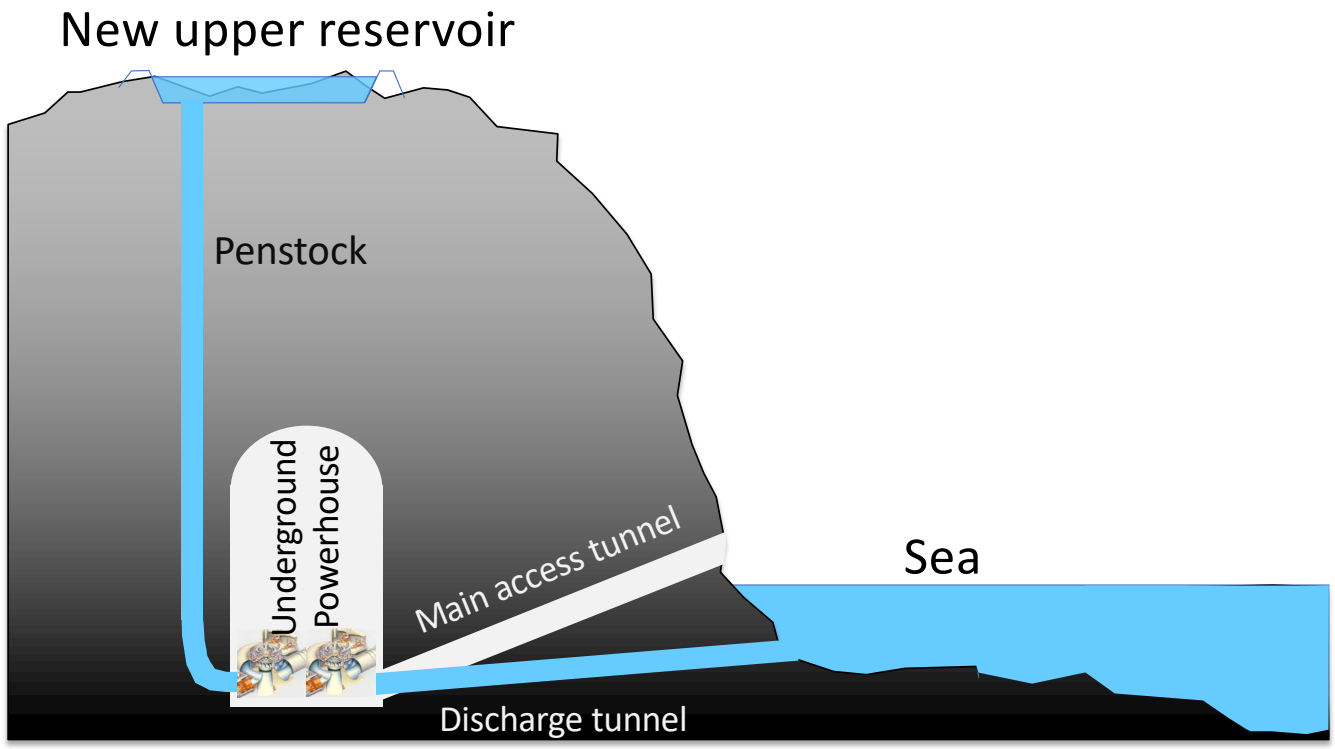


56 plants 14 GW
(technically feasible)

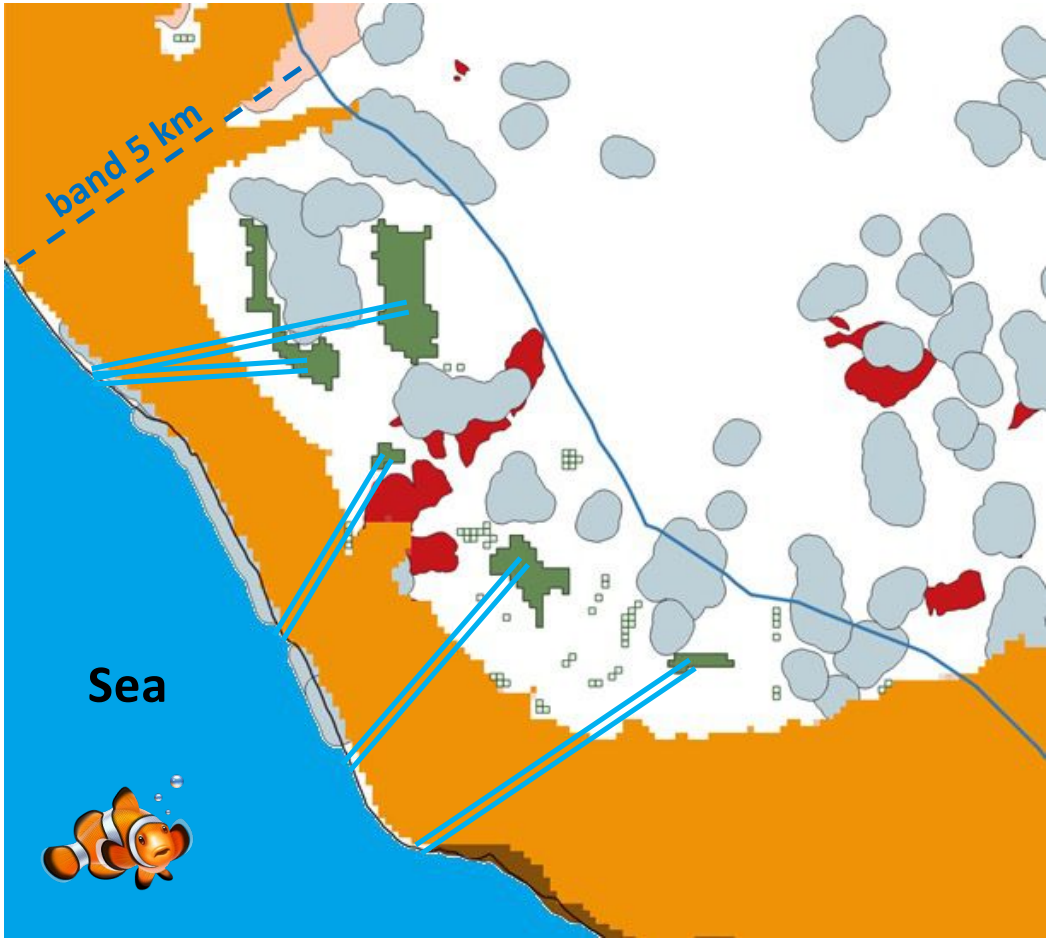
Terna forecasts by 2040
11 GW of new storage
systems need to be
added to the 7,6 GW of
available pumped
plants.

21 plants
9 GW
80 GWh storage

Type 3: Seawater Pumped hydro storage



Seawater pumped hydro storage



EUAP 2011

SIC

Urbanized areas

Landslide risk high danger P3

Landslide risk very high danger P4

Heads less than 200 m

Area with slope less than 10%

New reservoir suitable area

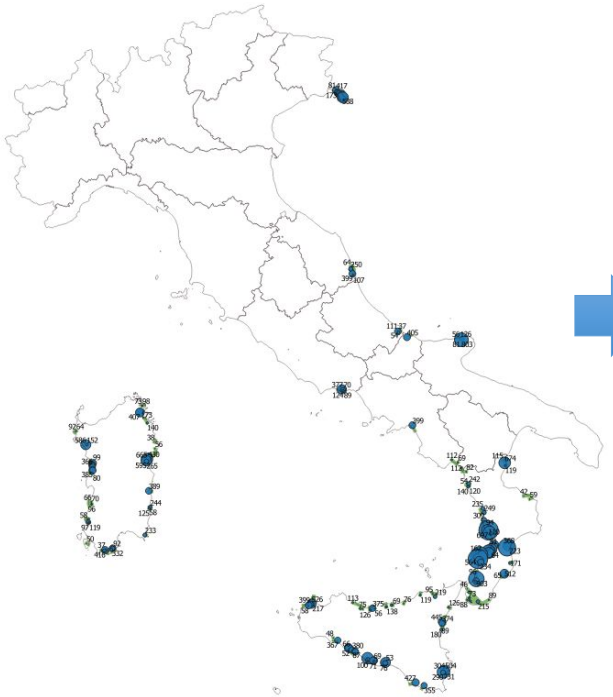
Discharge tunnel

New reservoir volumes:

< 5.000.000 m^3

> 500.000 m^3

Suitable seawater pumped plants



255 plants and 66 GW
(technically feasible)

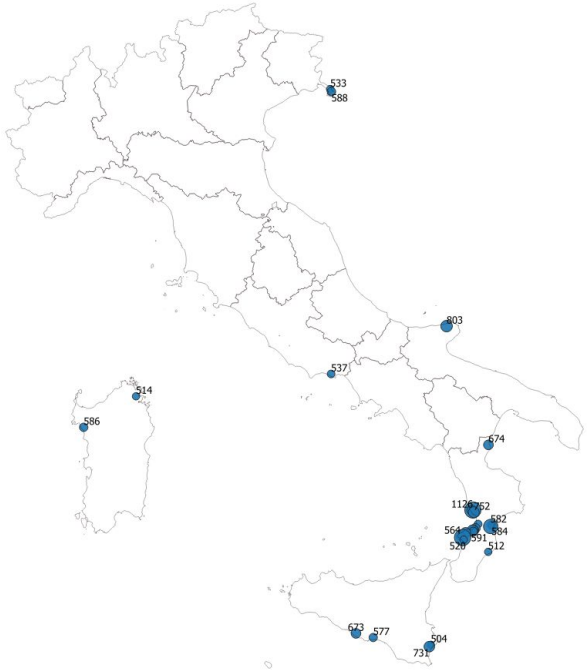
Arbitrary filter

- Cost/power ratio < 2 M€/MW
- Power greater than **500 MW**

Seawater plants

- 19 plants 19 GW
- 180 GWh storage

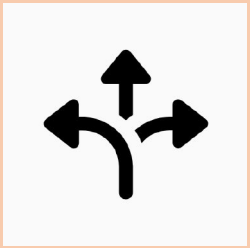
To be filtered considering economic, technical and environmental aspects
MCA (Multi-Criteria Analysis)



29 plants
19 GW
180 GWh storage

Multi-criteria Analysis

A. Fulfillment of Flexibility Services

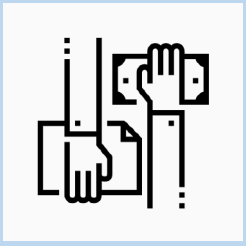


- A1. Ability to provide flexibility
  - A1.1 Management limitation of the available reservoir
  - A1.2 Power
  - A1.3 Sedimentation
  - A1.4 Drought
  - A1.5 Level variations
- A2. Need for local flexibility services
  - A2.1 Need for resources for network congestion resolution
  - A2.2 Concentration of RES in the area

B. Project economics

- B1. Specific cost of the plant
- B2. High voltage network nearby
- B3. Cost that induces economic benefit to the community

C. Ease of approval & implementation of the project



- C1. Multiple use competition
- C2. Ecological status of existing lakes
- C3. Overlap with protected and restricted areas
- C4. Impact in the construction phase

Do you want to be a decision maker?

If you want to **participate** in the calibration process of the method by creating suggestions and sharing knowledge, **please enter into the QR and leave your contact information.**

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Thank you for your attention

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Research activities carried out in the context of the National Recovery and Resilience Plan (PNRR) - Mission 2 - Component 2 - Investment 3.5 “Research and Development on Hydrogen", funded by the European Union - Next Generation EU, and performed in implementation of the Operative Research Program (POR) approved by the Ministry of Ecological Transition on 27.06.2022