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International Institute for Applied Systems Analysis
IIASA

Seasonal Pumped-Storage Plants: An Integrated Approach for Hydropower, Water Management and Energy Storage

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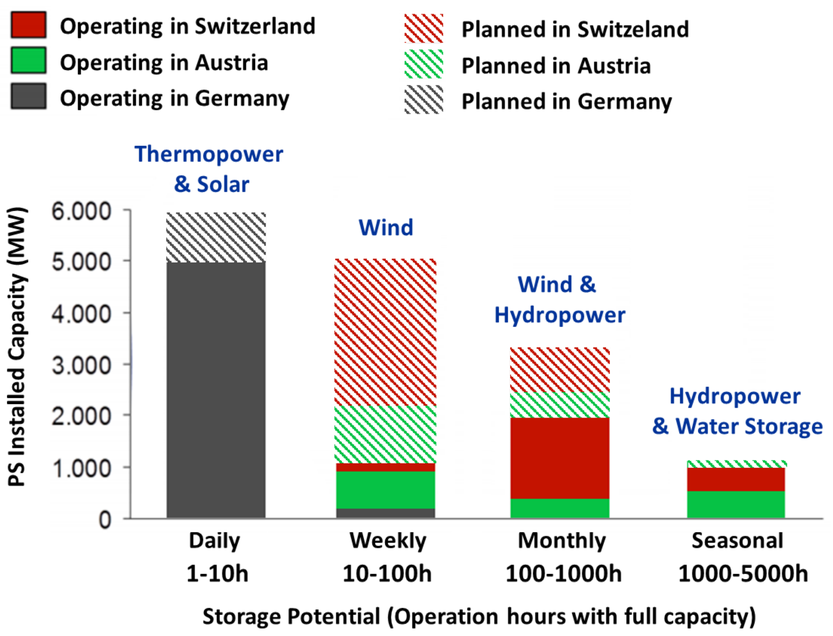
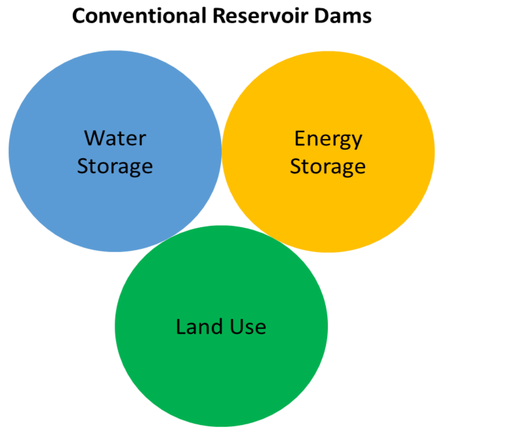
Motivation:

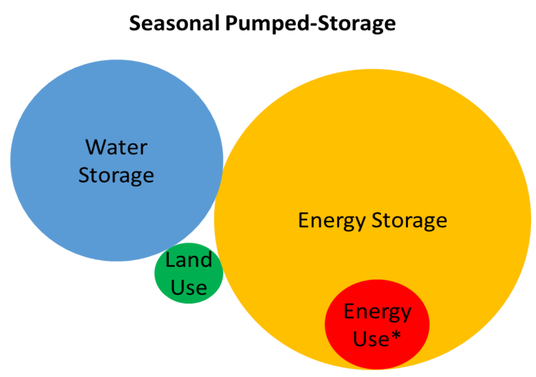
- Intermittent renewable energy sources such as wind and solar increasing energy storage demand.
- Large reservoir variations made possible with variable speed pump-turbines and asynchronous generators.
- Combine energy and water storage needs with low land requirements using seasonal pump-storage.



Pumping/ Generation Head & Storage Years	Multi-Purpose SPS Applications												Country
	Energy						Water					LD	
	PG	IS	TO	HP	ES	HO	WS	ER	TW	BT	FC	LD	
High (500-800m) One year storage	•••	•••	•••	•••	••	•	•	•••	•	•	•	•	Austria, Switzerland
High (500-800m) Multiple years storage	•••	•••	•••	•••	•••	•	••	•••	••	••	•	•	Norway, Sweden
Medium (100-500m) One year storage	••	••	••	••	••	••	••	••	••	••	••	••	Canary Island
Medium (100-500m) Multiple years storage	••	••	••	••	•••	••	•••	••	•••	•••	••	••	New Zealand Iceland, Canada, Brazil, Australia, USA
Low (50-100) Multiple years storage	•	•	•	•	•	•••	•••	•	•••	•••	•••	•••	USA

Peak Generation
Intermittent Generation Storage
Transmission Optimization
Hydropower Generation
Energy Security
Cascade Hydropower Optimization
Water Supply
Evaporation Reduction
Transport with Waterways
Inter-Basin Transfer
Flood Control
Land Requirement

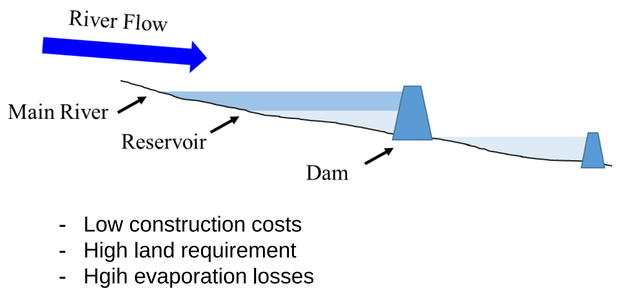




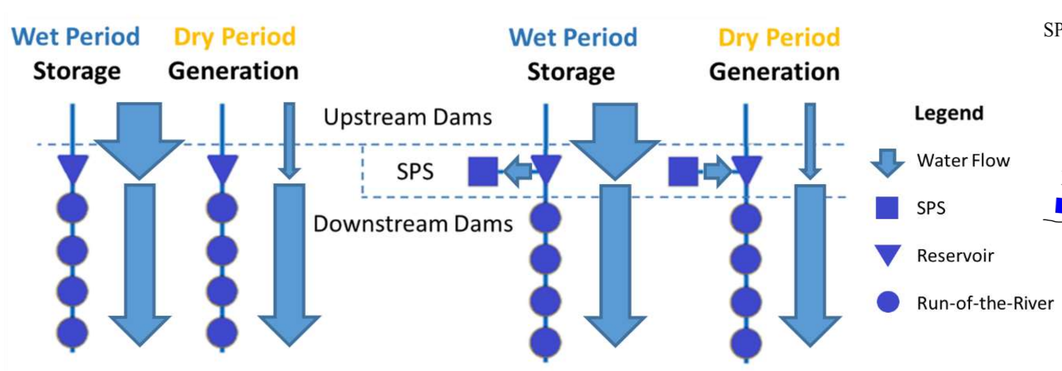
Method:

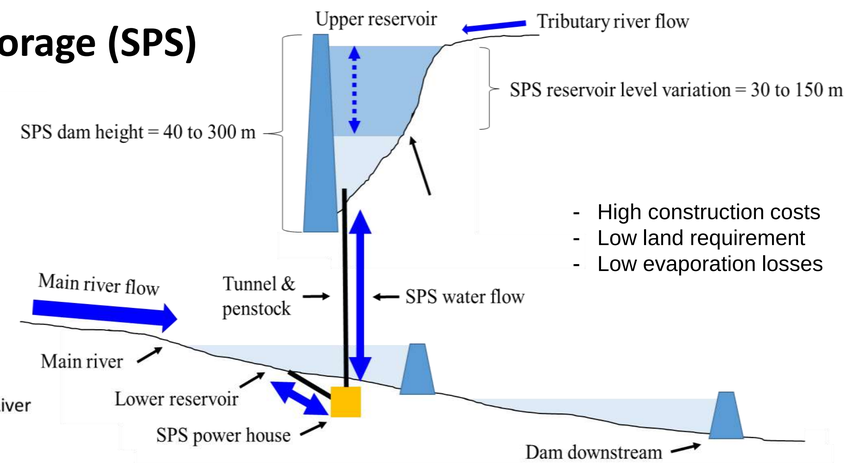
- Compare conventional reservoir dams with seasonal pumped-storage plats. Seasonal pumped-storage consists of building a large storage reservoirs parallel to the main river and use it for energy and water storage.

Conventional Reservoir Dam (CRD) vs **Seasonal Pumped-Storage (SPS)**



- Low construction costs
- High land requirement
- Hgih evaporation losses

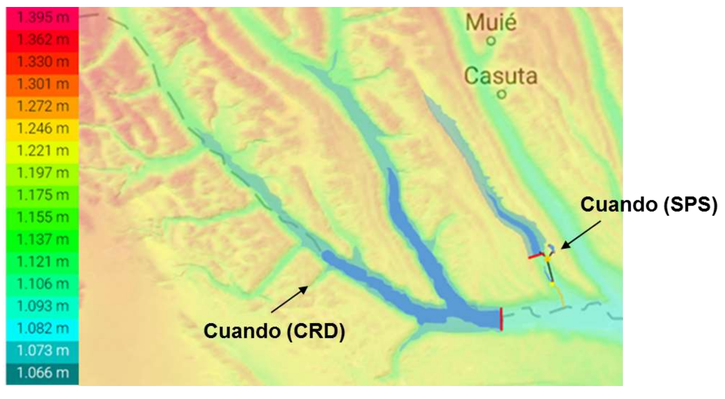




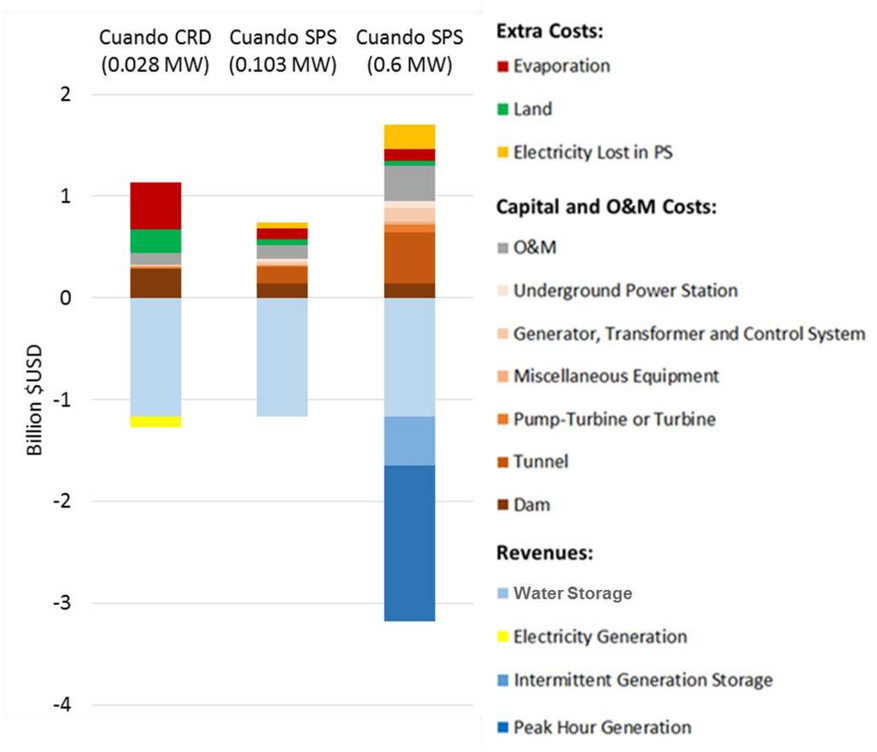
- High construction costs
- Low land requirement
- Low evaporation losses

Results:

- SPS can be cheaper then CRD due to its multiple uses and lower land and evaporation costs. Case studies have been developed on Zambezi River Basin and in Brazil.



Characteristics	Cuando CRD	Cuando SPS
Maximum level (m)	1140	1210
Minimum level (m)	1120	1150
Level variation (m)	20	60
Downstream level (m)	1100	1120
Upstream level (m)	-	1240
Minimum pumping height (m)	20	75
Dam height (m)	40	90
Dam Lenght (km)	4	2
Tube (km)	-	12 + 5 Chan
Maximum Flooded area (km^2)	559.8	131.7
Minimum Flooded area (km^2)	279.9	73.2
Floded area variation ratio	2	1.8
Useful stored volume (km^3)	4.4784	4.48
Average flow (m^3/s)	80.0	82.6
50% of Total Flow (km^3/year)	1.23	1.27
Ratio with useful stored volume	3.64	3.52
100% of flow (km^3/year)	2.46	2.54
Ratio with seful stored volume	1.82	1.76
Catchment (km^2)	30509	30509
Power capacity (MW)	26	103



Conclusions:

- SPS plants should be used in locations where CRD are not viable due to it topography.
- The seasonal water storage process can be combined with the need for energy storage, reducing both costs.
- SPS have higher construction costs than CRD, however, have lower land requirements and evaporation losses.
- SPS are particularly appropriate for locations with low water.

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