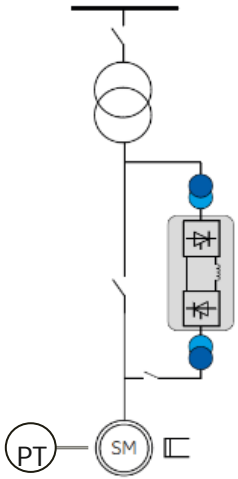
Benefits of Modern Pumped Storage for Power Station and Grid Operators

Alexander Schwery

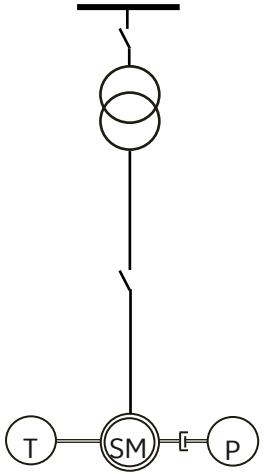
PSP System Technologies

Fixed speed pumped storage

Reversible PT

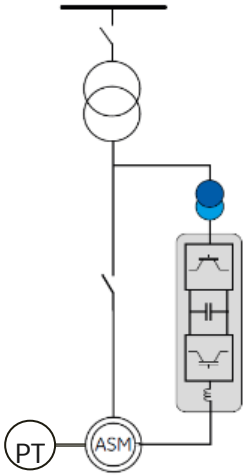


Ternary Group

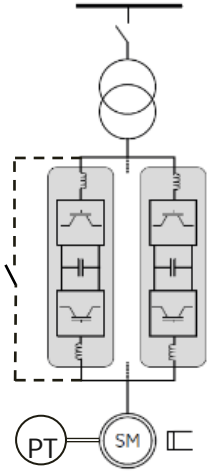


Variable speed pumped storage

Double fed

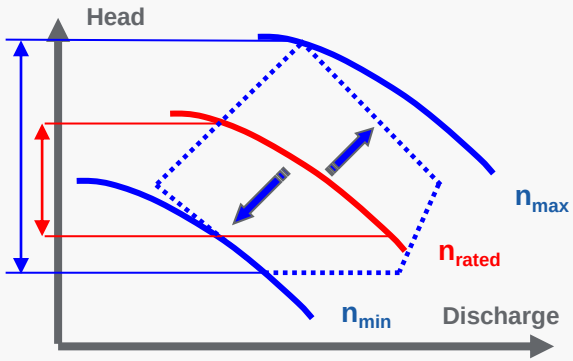


Fully fed



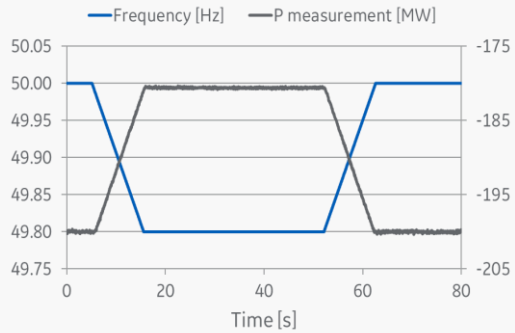
Advantages – Variable speed pumped storage

Higher head range



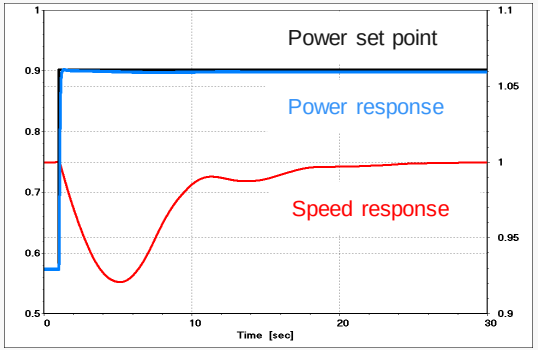
- More possible sites become economically interesting
- Allowing for higher storage capacity at a given site

Power control in pump mode



- Primary frequency control in pump mode
- Flexible adjustment of power for peak shaving
- Reducing curtailment of wind and solar

High dynamic response



- Fast frequency response for grid stability
- Improved grid restauration after black out
- Flexible adjustment of power for peak shaving

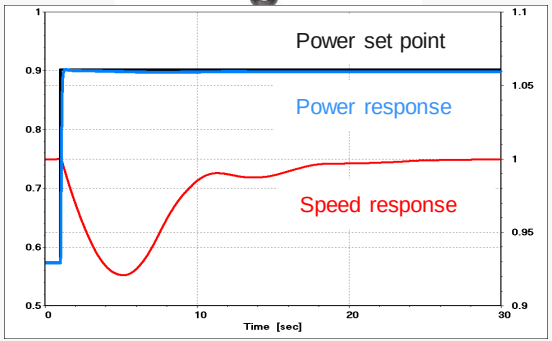
Varspeed PSP vs. Batteries

Storage capacity

Source: www.mitsubishielectric.com

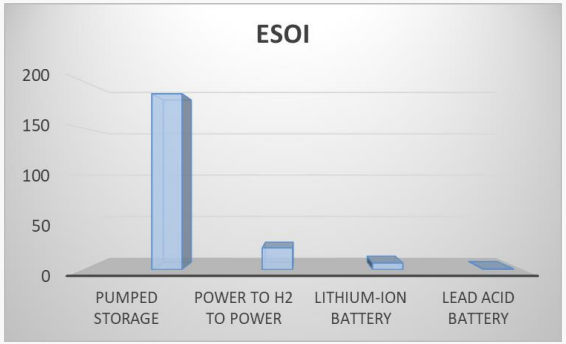
	Linthal	Large Bat.
Power	1000 MW	50 MW
Energy	34 000 MWh	300 MWh
Containers	28 500	252

Dynamics



Ecology

$$ESOI = \frac{\text{Stored energy returned over lifetime}}{\text{Energy required for manufacturing}}$$



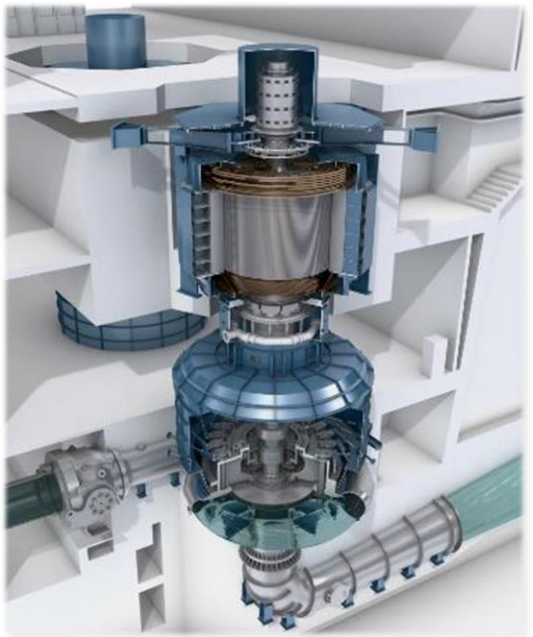
Source:SATW Energy performance Switzerland Report

Double fed unit example Linthal

Electrical machine (indicative data)

Double fed asynchronous units	IAV 470/320/12
Number of units	4
Apparent power	280 MVA
speed	470-530 min^{-1}
Rated voltage	18 kV
Rotor weight / J / H	410 t / 1200 tm^2 / 5,8 s

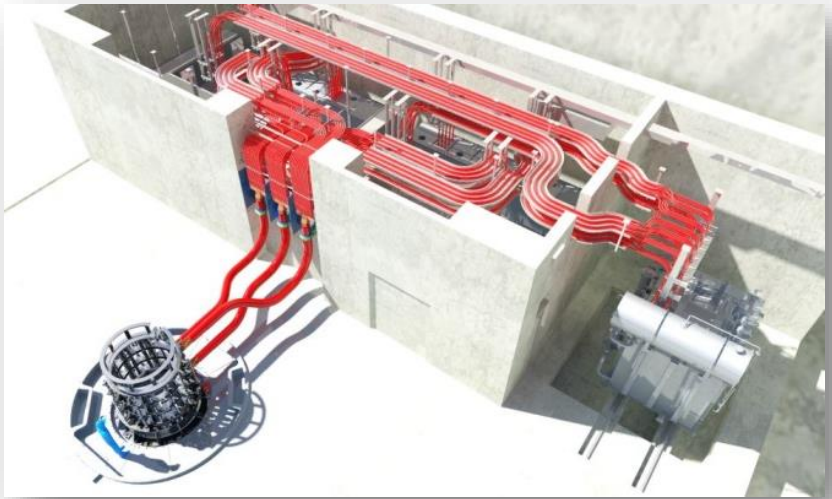
Power plant in operation



Double fed unit example Linthal

Converter per unit (indicative data)

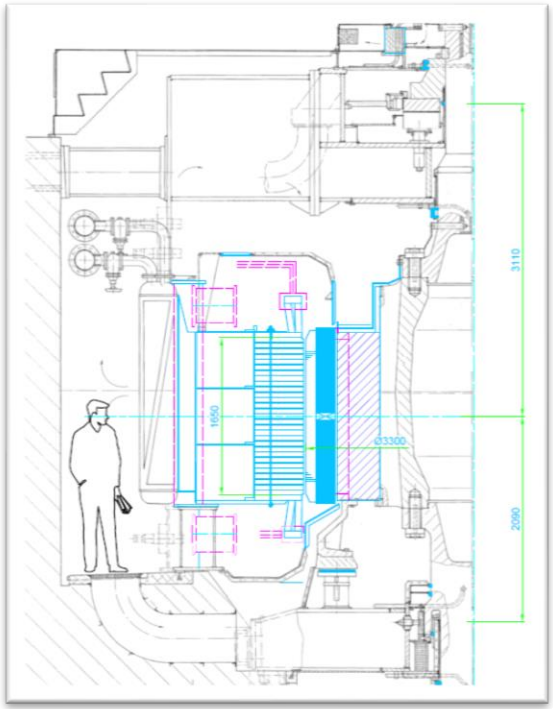
Type	3 Level VSI AFE
4 Modules per machine	MV7311
Apparent power	50 MVA
Rated voltage	3,3 kV (rms)
Converter room - 4 converter modules - Control, Protection - Cooling	17m x 7m
Transformer	Double delta-star
Apparent power	28 MVA
Transformer space	6m x 6m



Fully fed unit example Malta Oberstufe

Electrical machine (indicative data)

Synchronous salient pole machine	SAV 470/320/12
Number of units	4
Apparent power	80 MVA
speed	240-515 min^{-1}
Rated voltage	18 kV
Rotor weight / J / H	236 t / 115 tm^2 / 1,9 s

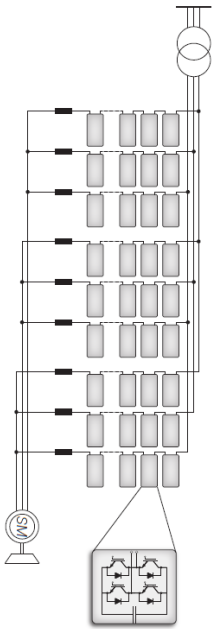


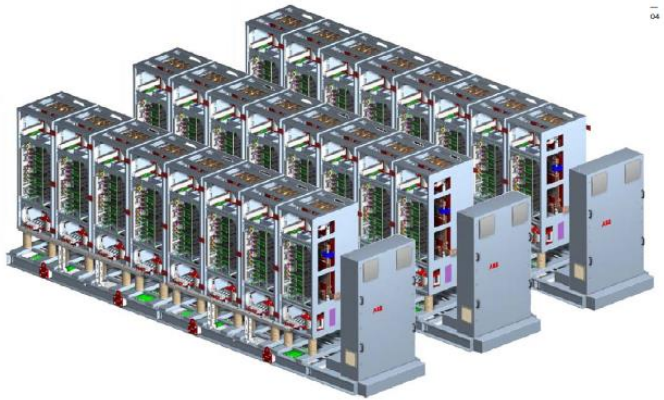
Power plant in operation

Fully fed unit example Malta Oberstufe

Converter per unit (indicative data)

Type	MMC - D
Apparent power	85 MVA
Rated voltage	18 kV (rms)
Converter room (Not including control, cooling and filter)	27m x 8m
Transformer	Star-delta
Apparent power	85 MVA
Transformer space	6m x 3m

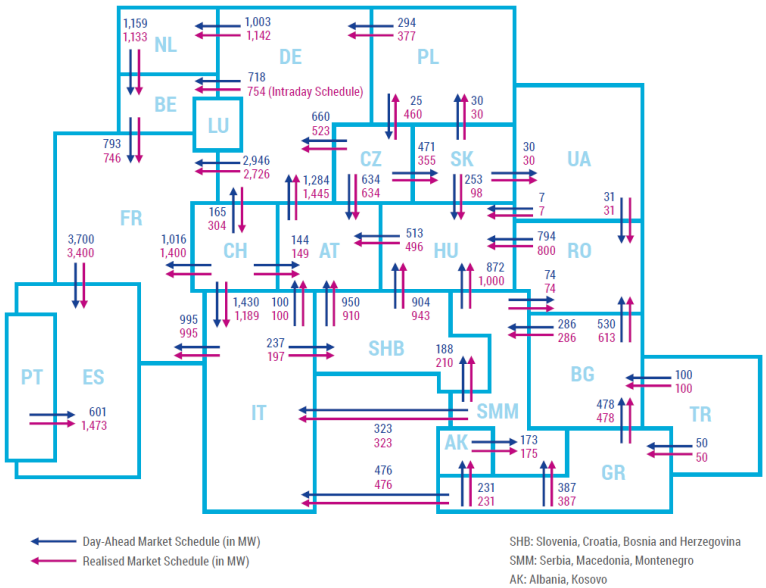




Source: curtesy of ABB (typical not Malta)

Added value of flexible units for the grid

Situation before the grid separation



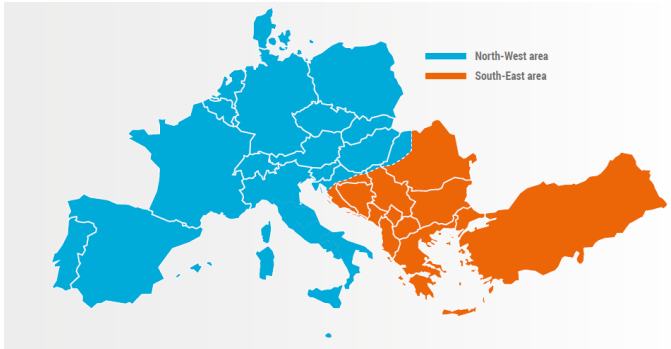
Situation before the grid separation

- Warm weather in the east and colder weather in the west
- Holidays period in the east
- High load shift from east to west
- High load angles in the east
- Predicted situation without unplanned unavailability
- Draft report from entso-e available

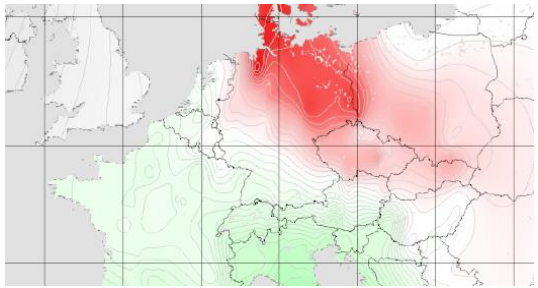
Source:https://www.entsoe.eu//

Added value of flexible units for the grid

Grid sepation

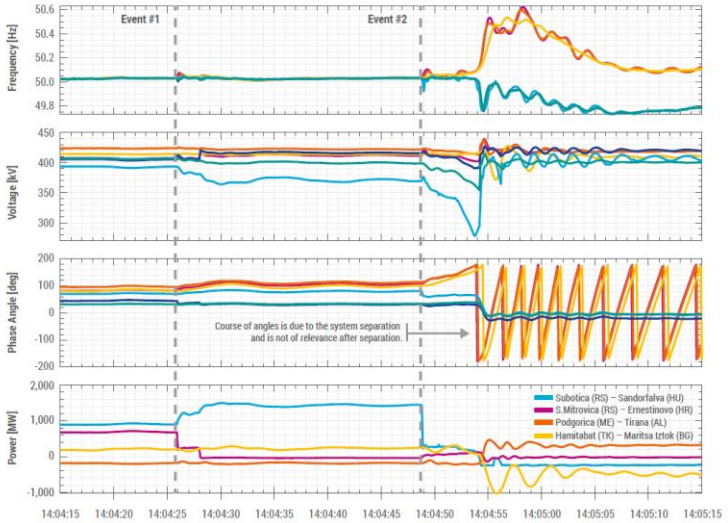


January 2021



November 2006

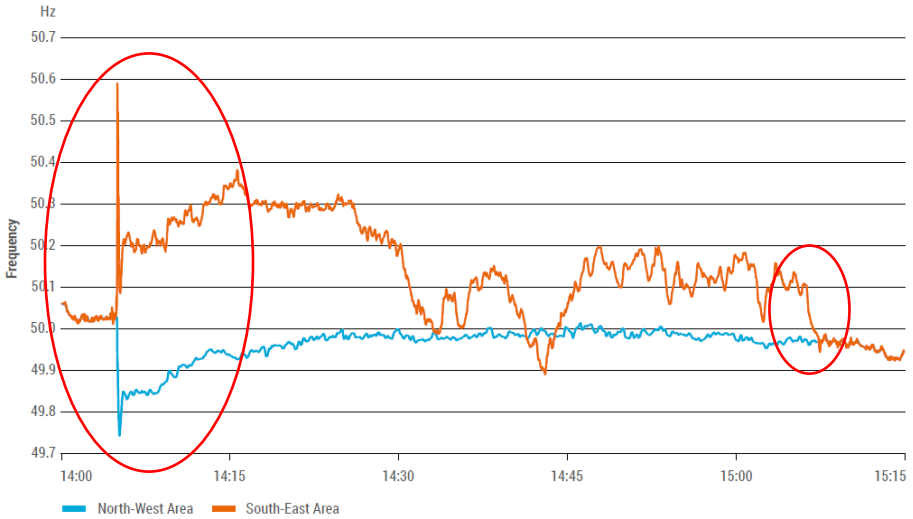
Sequence of events



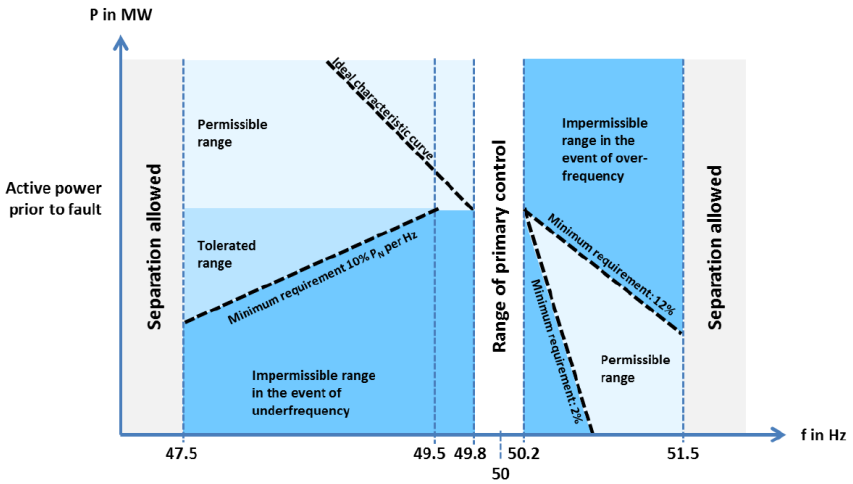
Source:https://www.entsoe.eu//

Added value of flexible units for the grid

Grid sepation



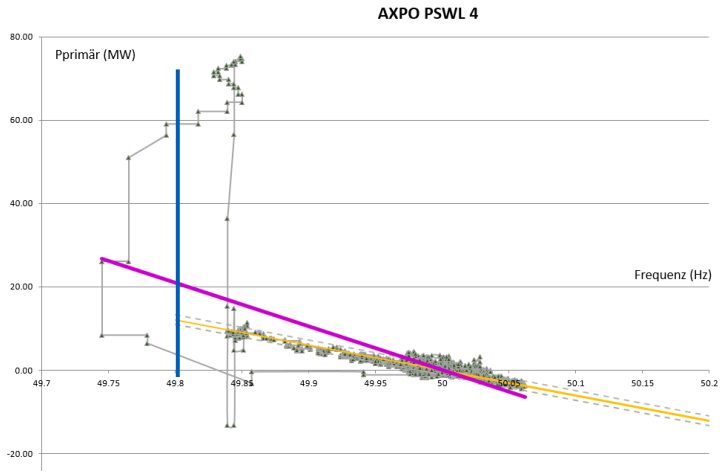
Grid code (RFG)



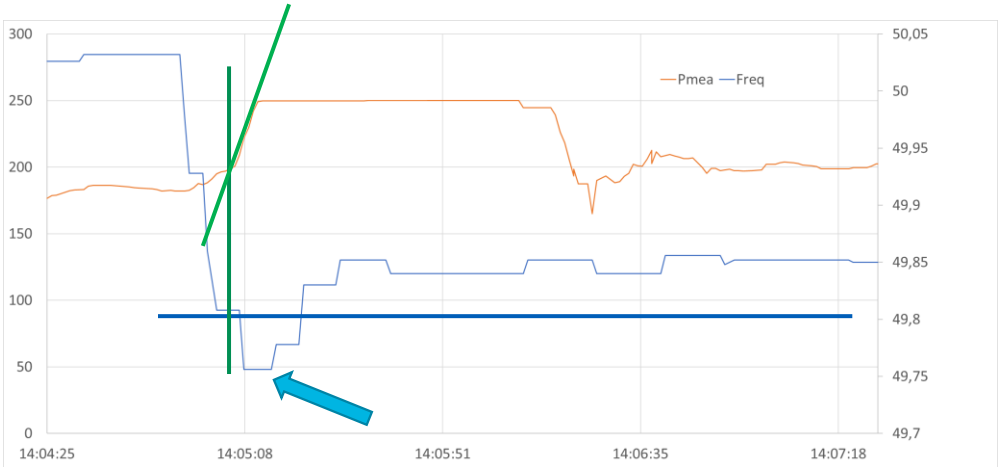
Source:https://www.entsoe.eu//

Added value of flexible units for the grid

Contribution of one Linthal unit



Contribution of one Linthal unit (sequence)



Source:https://www.entsoe.eu//

Conclusion

Take Away

- Most economic and ecological way to store large amounts of energy
- Highly dynamic and flexible storage devices allowing for further integration of new renewables

GE HAS BEEN IN THE HYDROPOWER INDUSTRY FOR MORE THAN 100 YEARS, HAS THE LARGEST INSTALLED BASE OF HYDRO STORAGE UNITS, AND HAS THE UNIQUE R&D MEANS AND KNOW-HOW TO PURSUE HYDRO'S DEVELOPMENT.