K. Schneider

Pumped Storage in Germany

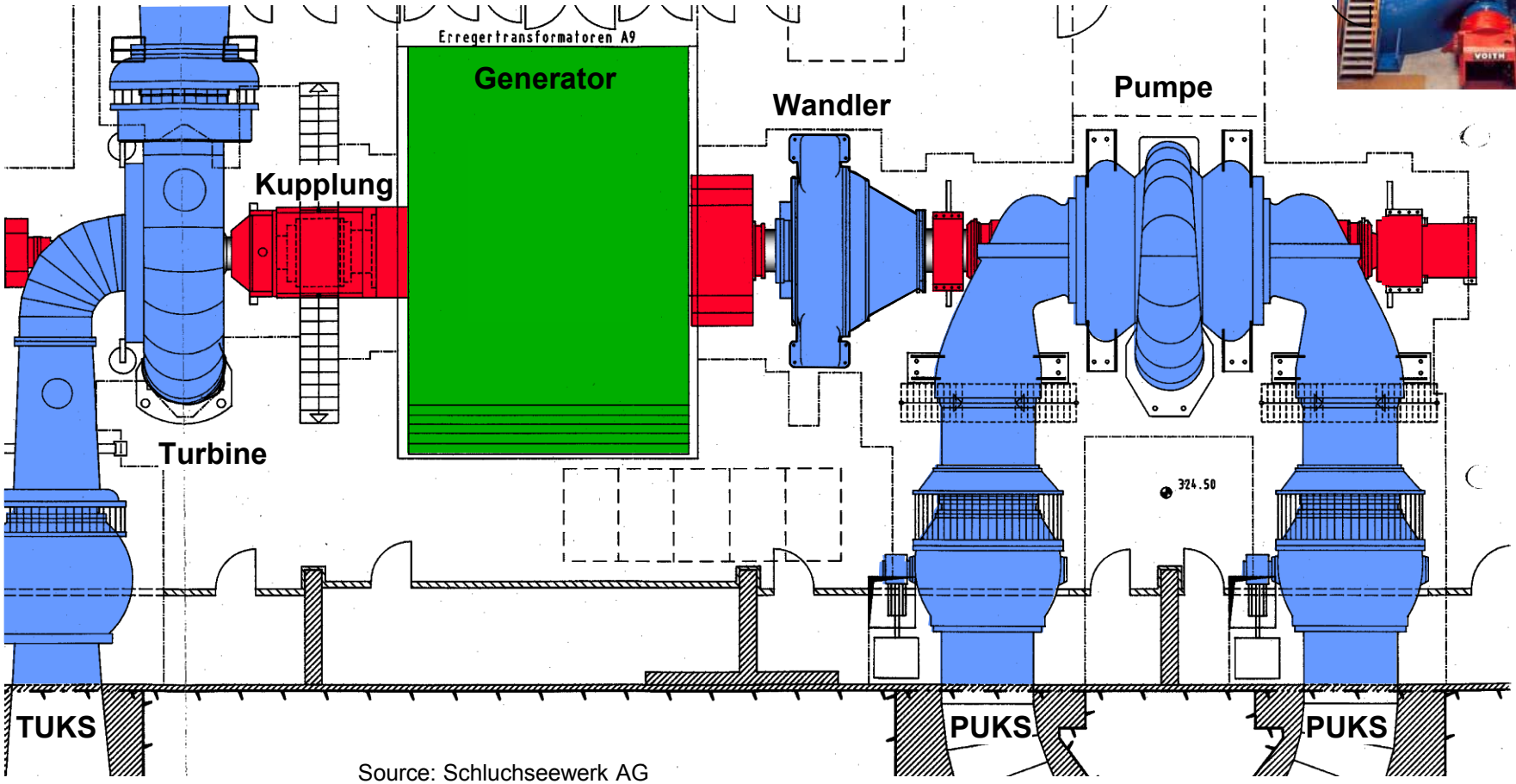
- Benefits, barriers, opportunities -

PSP Häusern/Germany

- 4 vertical units (turbine, 2-stage pump with converter, motor generator)
- Turbine operation 4 x 35 MW
- Pump operation 4 x 25 MW, 4 x 10 m^3/s
- Commissioning 1931

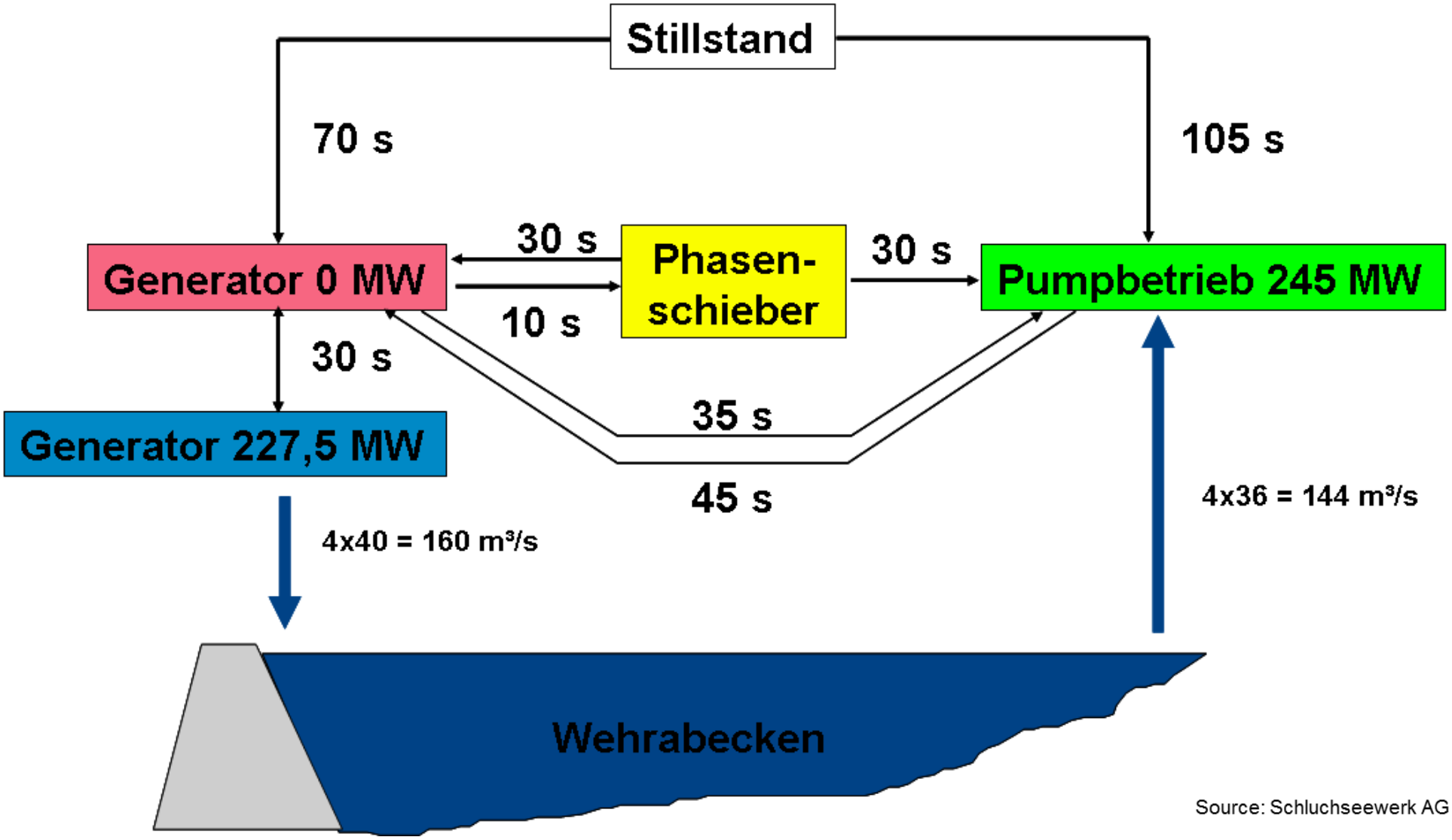
Source: Schluchseewerk AG

PSP Wehr/Germany: Ternary unit



Source: Schluchseewerk AG

PSP Wehr: transition times



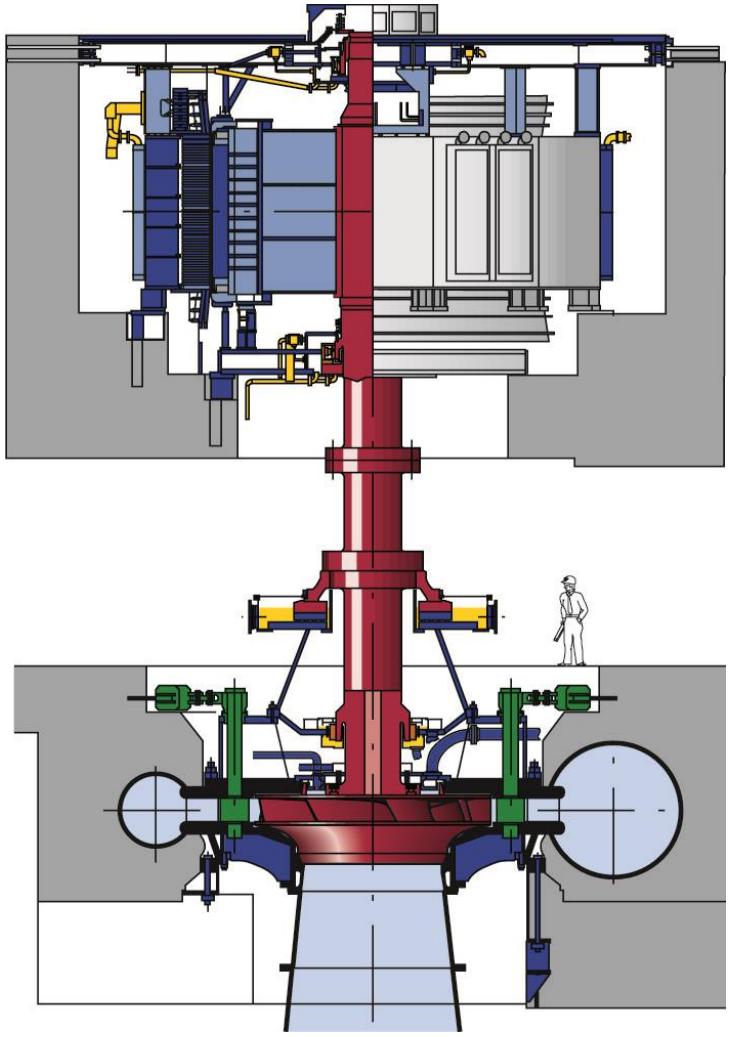
Source: Schluchseewerk AG

Goldisthal/Germany: reversible pump turbine

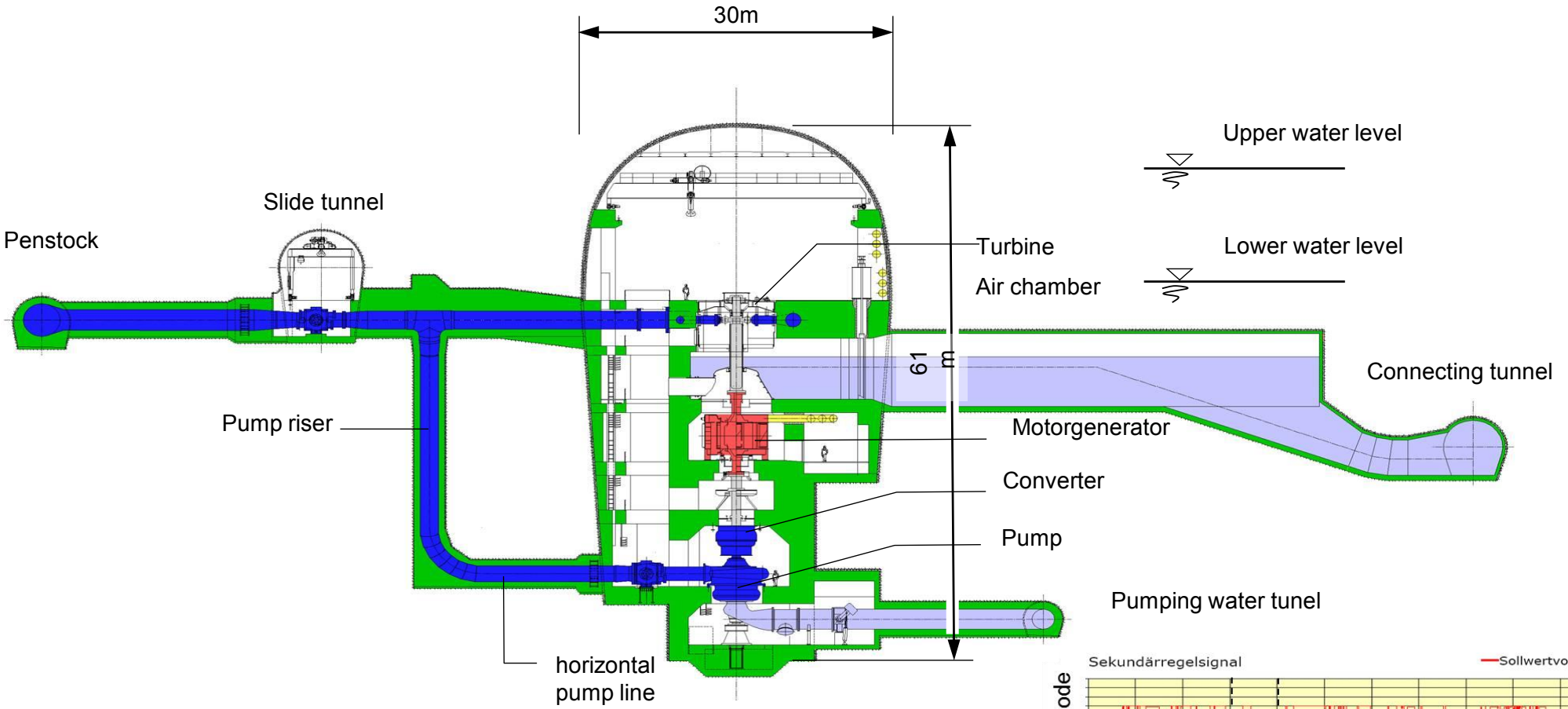
		(synchron)	(asynchron)
Number of units	[-]	2	2
runner diameter	[m]	4.59	4.59
nominal speed	[rpm]	333	300-346
max. turbine output	[MW]	325	300
max. pump power	[MW]	262	291
max pump head	[m]	338	339

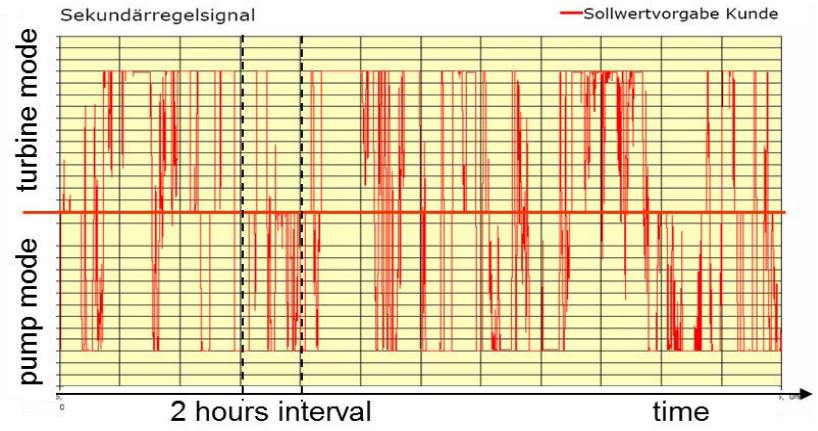
variation of pump power > 100MW

Source: Vattenfall, Voith Hydro



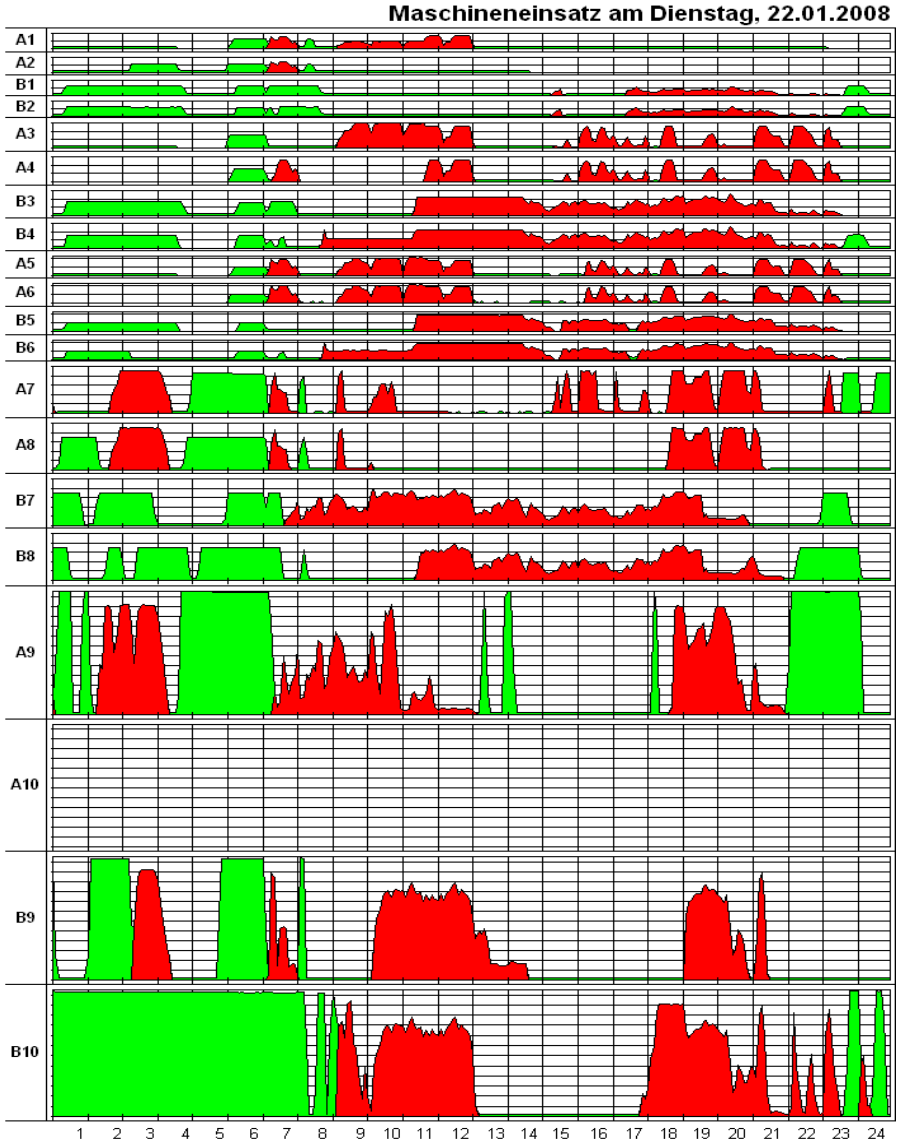
Kops II/Austria: Hydraulic short circuit





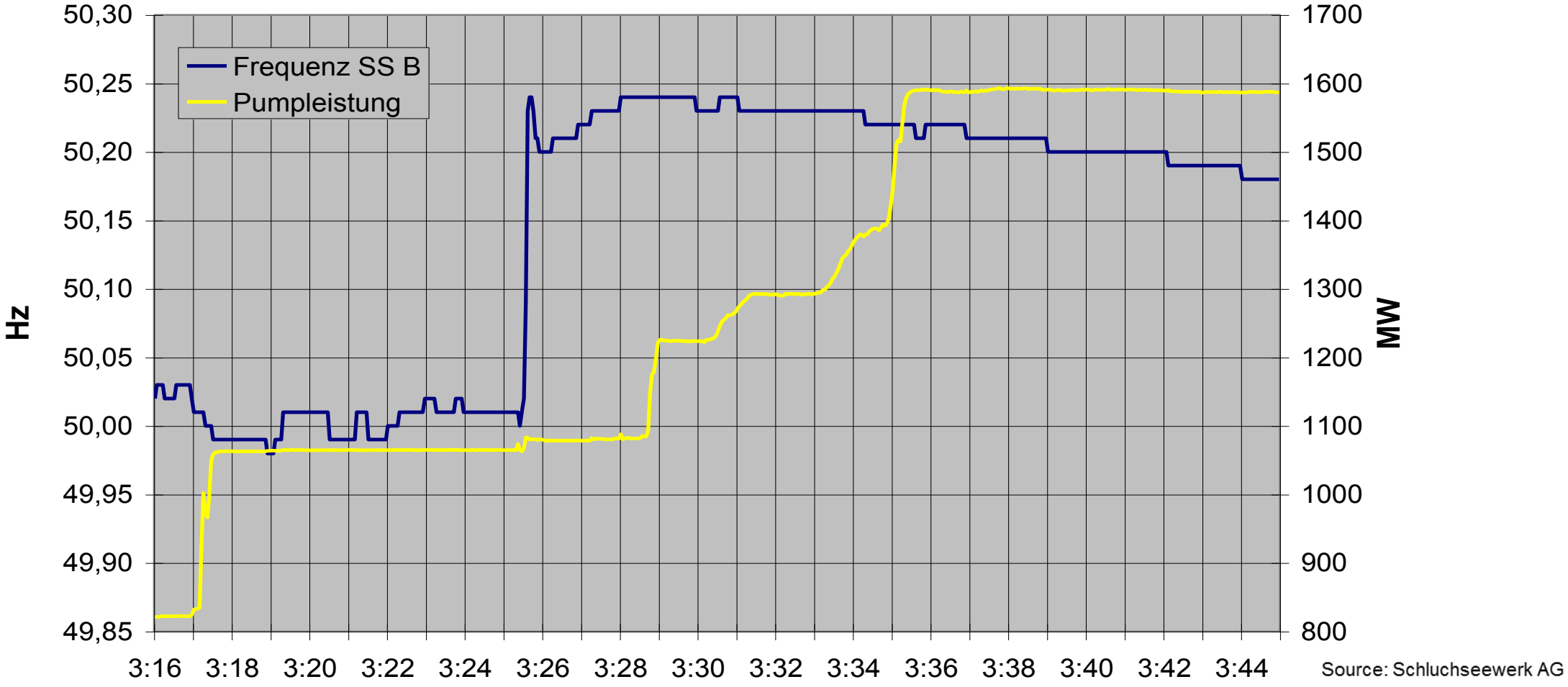
Source: Vorarlberger Illwerke AG

PSP operation



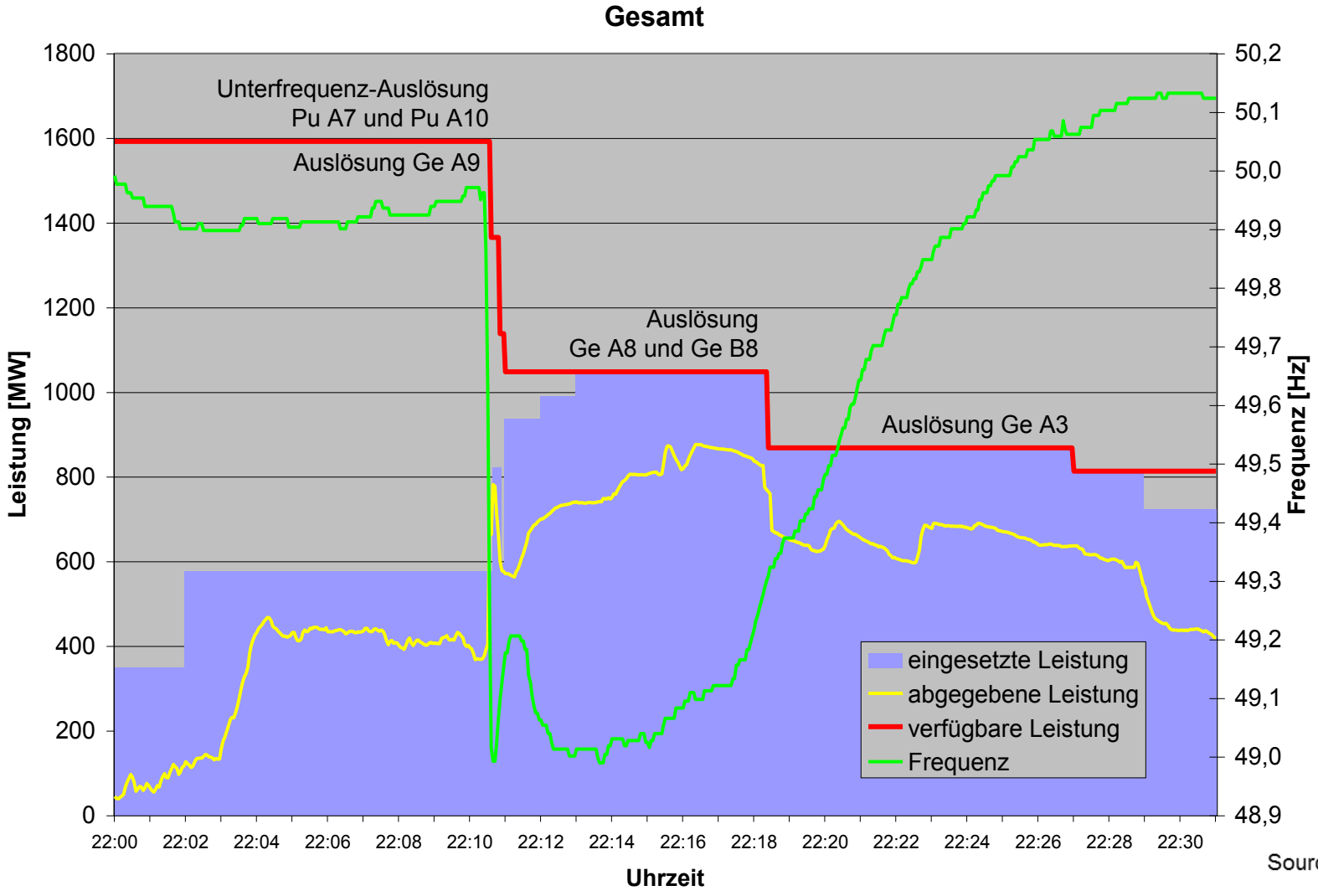
Source: Schluchseewerk AG

Power failure in Italy on 28.09.2003, 03.25 hours
Frequency / Pumping capacity



Source: Schluchseewerk AG

System incident - 4 November 2006: frequency and capacities



Source: Schluchseewerk AG

Energiewende: challenges and solutions

Challenges

- Increase of volatile generation
- Inaccuracy in forecasts
- High load gradients
- Decreasing share of conventional power generation

Solutions

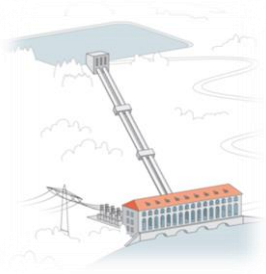
- Network expansion
- Flexible power plants
- Demand side management
- Energy storage

Source: Schluchseewerk AG

Storage technologies

Pumped storage:

+ The only large-scale power storage technology worldwide
+ Proven over decades and throughout the world
+ High efficiency of large-scale facilities
+ Most economical storage technology
+ Highest system quality
+ Development potential
- Intervention in nature

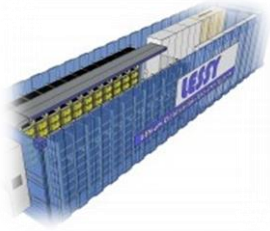


(Adiabatic) Compressed air storage:

+ 2 diabatic facilities in operation in the world
+ Relatively inexpensive
+ Relatively high efficiency
- No adiabatic facility built yet
- Site competition for salt cavities (gas and CO2 storage)

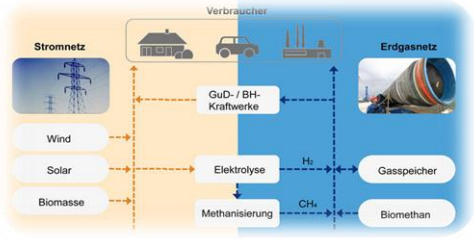
Batteries:

+ Short reaction time
+ High efficiency
- Limited number of load cycles
- No large-scale utilisation so far



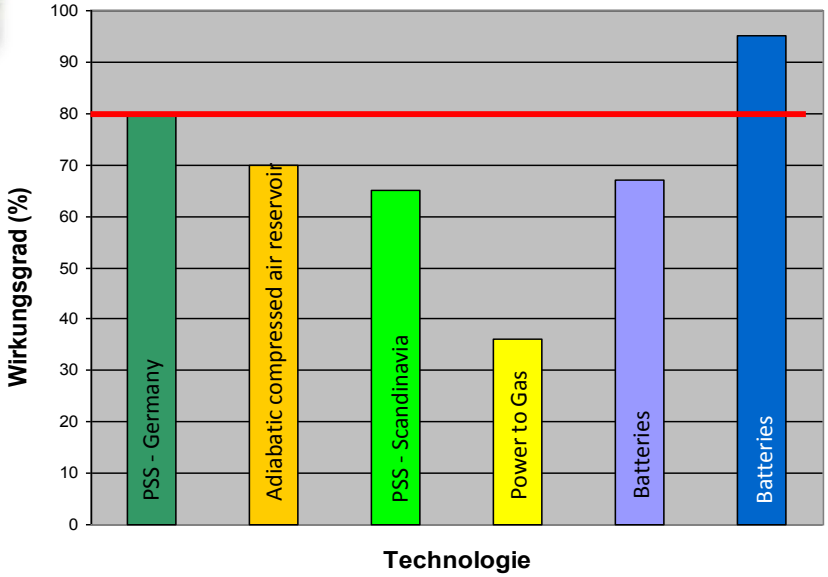
Power to Gas:

+ Potential for long-term storage
- Relatively high costs
- Low efficiency
- Still in the developmental phase



E-Mobility:

+ Relatively high efficiency
- Limited development potential
- High costs of infrastructure development
- Battery wastage
- Consumer acceptance
- Still in the developmental phase

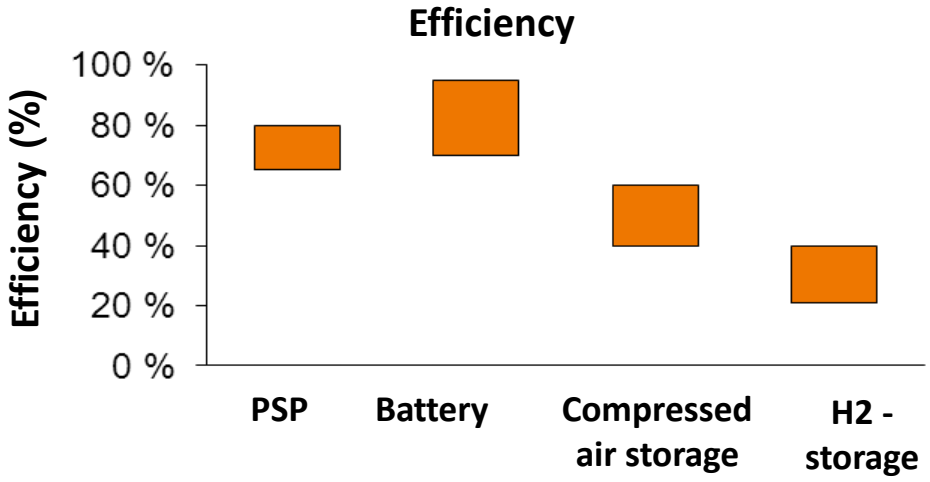


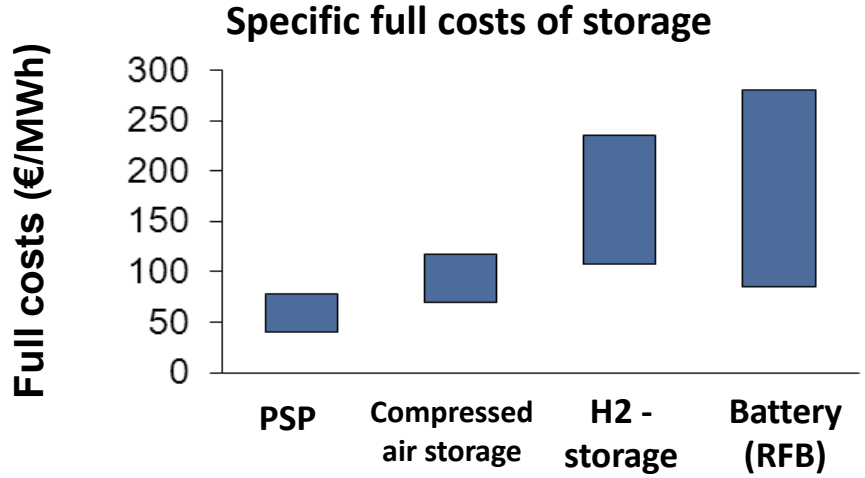
Quelle: NABU

Source: BDEW / dena

Storage technologies (2)

Pump storage technology is currently the most efficient storage technology





- PSP **have a high efficiency**
- PSP have **long service lives** and **low costs** of storage
- PSP have the **lowest full costs**

But:

- PSP involve **high investment costs**
- PSP therefore require **long amortisation periods**

Source: Schluchseewerk AG

Storage development

Energy storage is necessary for grid stability and load-balancing

Control energy and ancillary services

Goal: Grid stability

Storage of energy and load balancing

Goal: Balancing fluctuations in generation and demand

Short-term

Long-term

- **Pumped storage**
- **Compressed air storage**
- **Battery**
- **Hydrogen storage**

Source: Schluchseewerk AG

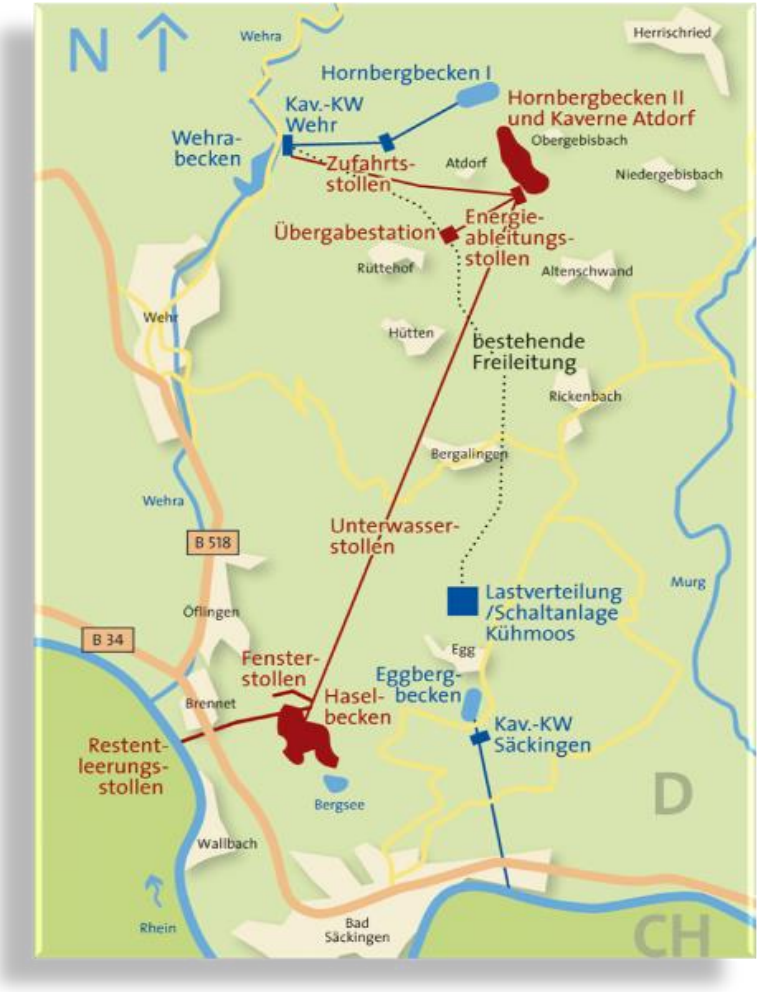
PSP Atdorf - project overview

- Power ouput 1,400 megawatts
- Storage volume 9 million m3
- Head 600 metres
- Capacity 13 gigawatt hours

- Total investment € 1.6 billion
- Construction time 5-6 years

Plus:

- **No** settlements in construction site area
- **No** new overhead line route necessary
- **Power plant compound** at an existing site **can be used**



Source: Schluchseewerk AG

Atdorf – Status Quo

Timeline

Spatial planning decision	✓
Round table	✓
Planning approval	Data submitted
Planning approval decision	likely in 2015
Commissioning	after 2022

Economic situation

Up-front costs	About 4%
Expected project costs	about €1.6 billion

Source: Schluchseewerk AG

Benefits

- Mature storage technology
- High efficiency
- High flexibility
- Long-lasting, sustainable, CO_2-free

Benefits – „products“

- storage of surplus energy
- avoiding the down-regulating of RES-production
- reduction of conventional must-run capacities
- ramping: control of tall and steep power gradients in „+“ - and „-“ – direction
- momentum reserve (mass inertia, frequency stability)
- primary, secondary, tertiary control
- secured power
- reactive power, voltage control
- short circuit power
- safe grid operation (redispatch)
- black start capability

Barriers

- Over-capacity (RES are higly subsidized, feed in priority)
- Low CO2-prices
- Services of PSP are not remunerated according to their value (Flexibility, anxillary services, redisptach)
- Costly and lengthy authorization procedures
- Long realization time
- Public acceptance

In operation, projects, potential

- at present 31 PSP (6.4 GW; 37.4 GWh) in operation
- additionally 2 GW in Austria and Luxemburg in the German grid
- further 12 greater PSP-porojects in planning (4.4 GW; 40.6 GWh)
- Potential
  - Thuringia: 4.83 GW; 38.7 GWh
  - Baden-Wurttemberg
    - 201 „sites with low conflicts“: 116 GW; 928 GWh
    - „very low conflicts“, economically and technically very suitable:
      13 sites (19 GW)
  - Bavaria: 16 particularly suitable sites (11 GW; 66 GWh)

Economic efficiency

Theses

- The economical framework conditions for PSP have deteriorated dramatically.
- The rapid development in photovoltaics leads to a shrinking spread between peak and off-peak.
- The realization of new PSP-projects is uncertain.
  Projects to be implemented in the neighbouring states are also under discussion.
- Even existing reservoirs are under enormous economic pressure.
- Short-term political solutions are not to be expected; problem-solving approaches for the new market design with capacity mechanisms are only feasible from 2020 onwards.
- No adjustment between time of need and construction time needed for new PSP.
- To maintain and expand PSP-capacity a reliable framework is required.
- Exemption of grid fees would help existing PSP.
- The need for flexibility must be taken into account in the further discussion.

Thank you
for your attention