Unlocking Hydro’s Full Green Battery Potential

Green Energy Flexibility in a Dynamic Grid Landscape
Energy Transition Challenges

Increased flexible production like wind & solar creates new challenges for energy markets & the grid.

GRID CHALLENGES

MARKET VOLATILITY INCREASE
The Intermittent Renewables Challenge

Generation varies over time...

Huge amounts of storage capacity are needed to balance supply and demand in real-time.

Quelle: https://energy-charts.de
The Storage Problem

Energy transition problems and how hydro power is the silent giant hidden hero of the renewables transition
How to Solve the Storage Problem

Intelligent combination of storage mediums will be required to allow full integration of wind and solar.

**HYDRO STORAGE**
- Predictable
- Large storage volume
- Rapid reaction
- Not possible everywhere

**BATTERIES**
- De-central locations
- Rapid reaction
- Small storage volume
- Rare Earth mining

**DEMAND RESPONSE**
- De-central locations
- Limited dispatchability
- Limited storage capacity

**NEW TECHNOLOGIES**
- Large storage volume
- Central & large investment
- Larger storage volume & no rare earths
Batteries are Growing Rapidly

Batteries will grow almost 10x over the next decade...

... will they become the most important storage medium?

Hydro storage capacity still dwarfs batteries way past 2035

SOURCEs: https://www.statista.com/statistics/1307203/world-battery-storage-electricity-generation-capacity/
https://www.iea.org/articles/how-rapidly-will-the-global-electricity-storage-market-grow-by-2026
But viewing data in GW paints a very skewed picture...

<table>
<thead>
<tr>
<th>Load Factor - Full Load Hours</th>
<th>2020</th>
<th>2026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump-Storage Hydro</td>
<td>GWh/GW</td>
<td>53</td>
</tr>
<tr>
<td>Battery</td>
<td>GWh/GW</td>
<td>1</td>
</tr>
</tbody>
</table>

- Average storage capacity of batteries is ~1 hour and will develop towards 3 full load hours with technological advances
- Average hydro storage volume is ~3 DAYS (= 20x larger per GW)

We need minimum 12 HOURS to cover day/night consumption patterns, even longer for periods of no wind (‘Dunkelflaute’).

→ How does the picture look in GWh = Storage Volume (not Storage Capacity)?
Hydro Power Is & Remains the Green Battery

Hydro power will be the largest source of grid-scale storage for many more years

TODAY

- 20 GWh

- Battery = 0.2% of Hydro Storage Volume

- 8.500 GWh

- Hydro PUMP-STORAGE Capacity TODAY

2035

- 350 GWh

- 12.500 GWh

- Battery = 2.5% of Hydro Storage Volume

- Hydro PUMP-STORAGE Capacity 2035

But a significant part of hydro storage potential is not reflected in these figures because it is currently UNUSED.

→ Why does hydro storage potential go unused?

Sources:
- https://www.iea.org/articles/how-rapidly-will-the-global-electricity-storage-market-grow-by-2026
Why is hydro storage potential wasted?

Hydro plant operators have to balance many complex objectives, 24 hours a day - Inflow and reservoir level needs to be monitored continuously based on the weather and in tight interaction with environment.

Without real-time-monitoring, ‘small’ storage volumes (< 1 days) of full load hours remain unusable.
What does this mean in practice?

Without real-time process, significant hydro storage potential goes unused.

Hydro storage capability ranges from:
- SEASONAL → Likely used
- WEEKLY → Mostly used
- DAILY → Rarely used
- HOURLY Storage → currently mostly unused

How can we fix this and lift this potential?
Real-time reaction unlocks hydro storage potential

Predictive production planning in real-time makes also small hydro storage accessible as ‘green battery’ to the grid

**Real-Time**
Monitoring & optimal dispatch 365/24/7

**Data-Driven**
Models continuously learn & recalibrate based on data

**Automated**
Digitalize your process from water to money and increase profitability
CASE STUDY: Making hydro storage potential usable
Real-time optimisation of water flow in complex cascades is not possible with manual process.

TURBINE: 1 Francis
CAPACITY: 4.5 MW

HISTORICAL PROCESS:
• Fixed profile
• Manual hatch control

NO FLEXIBLE DISPATCH

➔ STORAGE POTENTIAL UNUSED
CASE STUDY: Making hydro storage potential usable

Real-time predictive planning empowers small & medium hydro storage to be available as ‘green battery’ to the grid

2019

→ 4.5 MW STORAGE POTENTIAL WASTED

2023

→ 4.5 MW STORAGE POTENTIAL USED

= 20,000 Tesla Power Walls
TODAY THE WORLD BOASTS

100,000 HYDRO PLANTS

OF WHICH

80,000 SMALL HYDRO PLANTS
& MOSTLY NOT DIGITALIZED

→ ASSUMING ONLY 5% OF THESE HAVE PHYSICAL STORAGE CAPABILITY
→ 3800 GWH OF STORAGE VOLUME POTENTIAL CURRENTLY UNUSED
Unlocking a ‘green’ battery to the grid
Making hydro available to the grid in real-time will unlock large storage potential without upfront investment need

3800 GWh of storage volume
estimated unused hydro potential

300 million Tesla power walls
@ 13.5 kWh
Let's tap into the unused potential

Enabling hydro storage potential with digitalisation is a huge lever in the energy transition.
CONCLUSION

1. Successful energy transition requires combination of multiple storage technologies

2. Use the ‘best option’ for each centralized / non-centralized use case based on physical availability

3. Invest significant resources to...
   • Develop (better) battery technology without rare earths and larger storage volume (‘solid state battery’)
   • Digitalize & financially incentivize hydro power to make huge storage potential available to the grid
Make Hydro a Power for The Future

optimize@hydrogrid.ai  +43 1 375 3333 30  hydrogrid.ai