

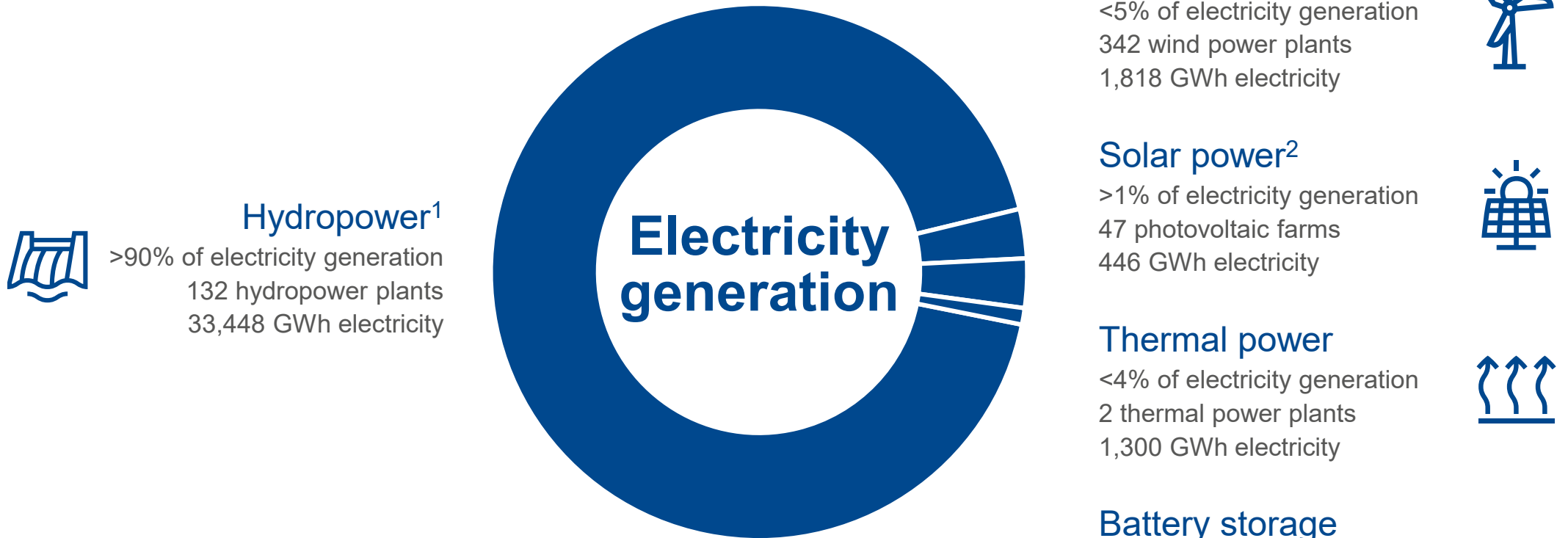
Why Aren't Large Redox Flow Batteries Implemented in Central Europe Yet? A Utility's Perspective


Dr. Karl Anton Zach
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VERBUND: Sustainable energy future

~96% generation from renewable energy sources



 **Hydropower¹**
>90% of electricity generation
132 hydropower plants
33,448 GWh electricity

Wind power
<5% of electricity generation
342 wind power plants
1,818 GWh electricity



Solar power²
>1% of electricity generation
47 photovoltaic farms
446 GWh electricity



Thermal power
<4% of electricity generation
2 thermal power plants
1,300 GWh electricity



Battery storage
<1% of electricity generation
15 plants
44 GWh electricity



¹including purchase rights; excluding non-fully-consolidated installations (Ashta 1&2 and Nussdorf)
²excluding leased/contracted installations
of which 27,989 GWh from run-of-river and 5,459 GWh from pumping/storage power plants
All figures ACTUAL production 2024

New technologies are continuously expanding VERBUND's strong energy storage portfolio and specifically address current challenges



(Pumped-) Hydro Energy Storage

The “green battery of the Alps” is constantly being expanded & made more flexible

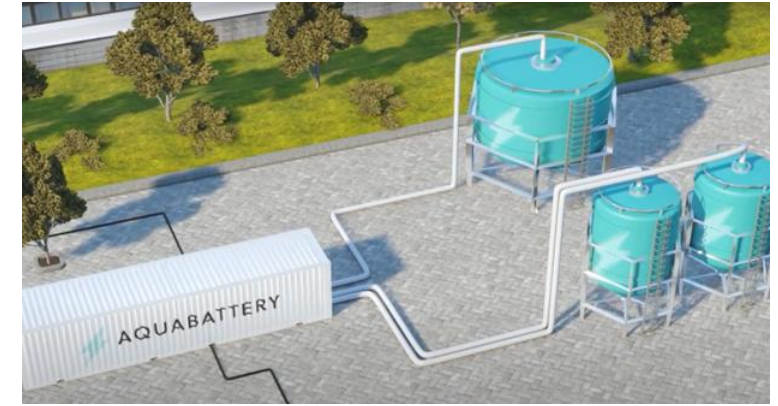
- 17 storage- and 6 pumped-storage power plants in operation
 - Power: ~3.800 MW
 - Storage capacity: ~1.800 GWh
- Additional flexibilization of two run-of-river hydro power plants with battery storage for the provision of grid services



Battery Storage Portfolio in Austria and Germany

Lithium-ion battery storage as the current state-of-the-art for applications with short duration energy storage

- Currently 15 large-scale lithium-ion battery storage systems in operation in DE and AT
 - Power: 110 MW / 130 MWh
 - Target: 1 GW battery power until 2030



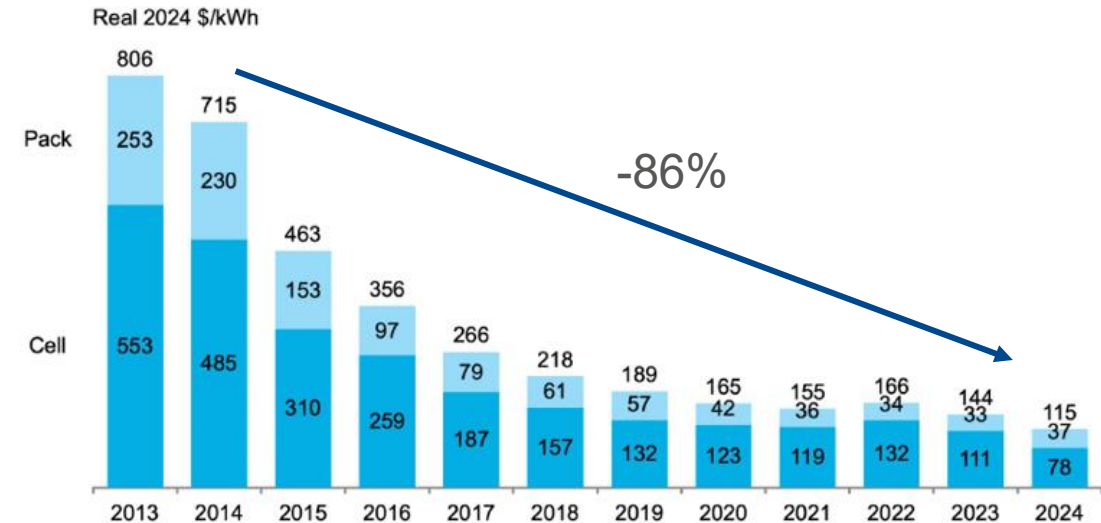
Pilot- and R&D-Projects with innovative (Long-Duration) Energy Storage

Technological innovations are pursued and pilot projects implemented

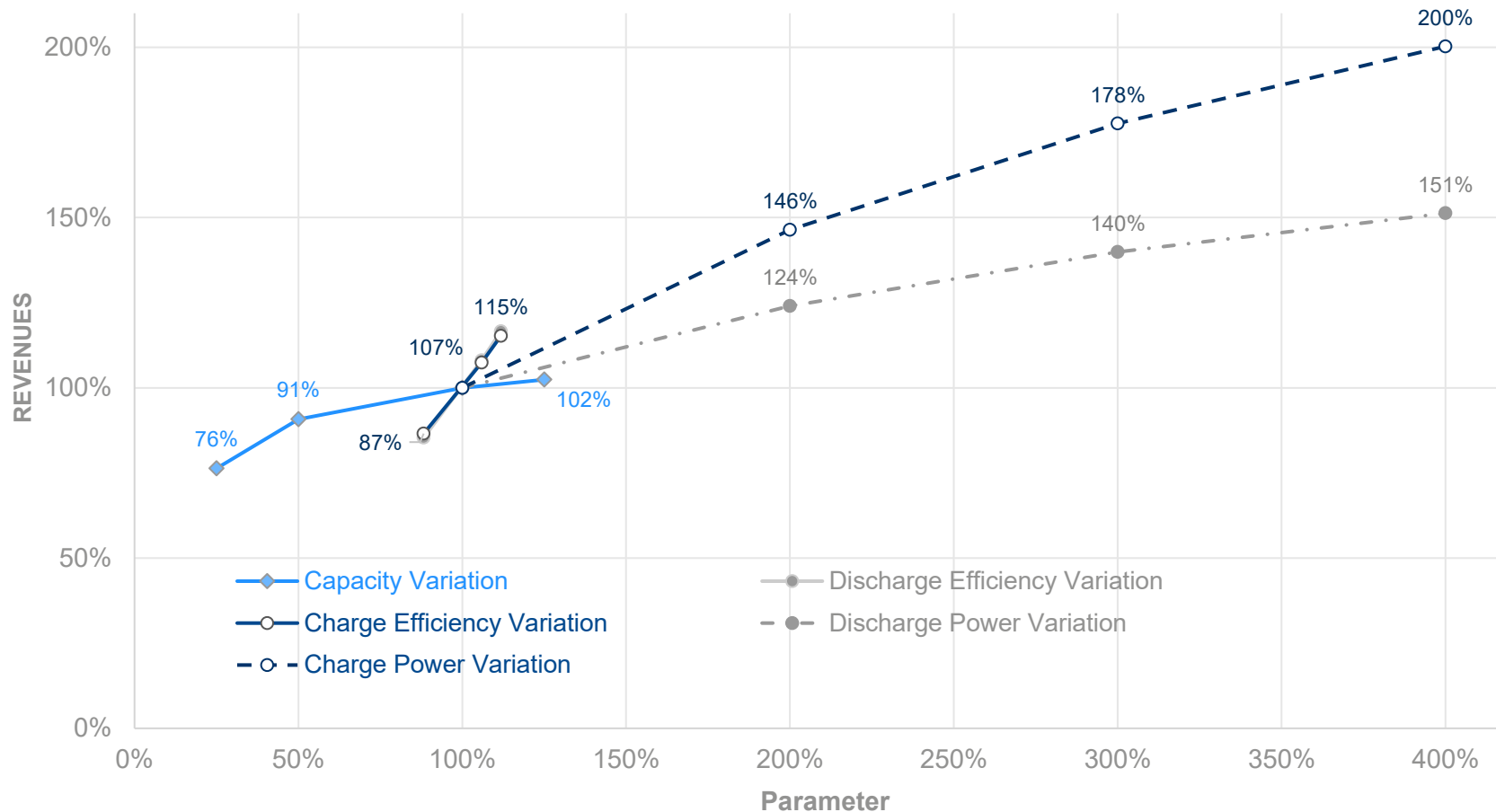
- >200 technology providers located
- Project pipeline with technologies with lower TRL in planning/implementation:
 - AquaBatt: (innovative acid-base-Redox-Flow with 5-10 kW power)
 - NESTOR & SIA: Pilot projects in MW-scale for wind-/PV-hybridisation

Lithium-Ion Batteries are dominating the market for short term storage up to discharge durations of 10 (?) hours and displace other technologies

- Due to economies of scale, LIBs have achieved an **86% cost reduction since 2013**, from 806 €/kWh to 115 €/kWh in 2024.*
- In the same period, due to technological advancement LIBs **improved service life, efficiency, and resilience** are steadily improving.
- In 2024 **69 GW / 169 GWh** of battery storage systems (BESS) were installed globally - **98% of which are LIBs**.**
- In Europe, BESS also recorded strong growth from **12 GW / 22 GWh to a total of 35 GW / 54 GWh in 2024**.***
- Falling capacity costs are leading to the **economic viability of projects with ever longer discharge durations**. While 1-hour storage systems were still primarily implemented in 2020, the figure was already 2.4 hours in 2024. **First LIB projects with a discharge duration of 8 hours** have already been announced or are currently being implemented.



Sensitivity Analysis for a 1 MW / 8 MWh show that lower discharge duration or higher power lead to favourable revenue / cost-factors



- 2 to 4 hours of discharge duration was optimum in the analysed period - a reduction of the installed capacity by 50% still leads to 91% of the revenues
- Charging power was more relevant than discharging power in the analysed period
- Changes in the efficiencies have an approx. linear effect on the revenues

Summary & Outlook: Higher discharge durations will get more important in the future with rising market share of volatile renewables

- Due to large cost reductions and technical advancements, **LIBs account for the majority of operational & planned projects in Europe** today.
- Projects with **2 and 4 hours of discharge durations clearly dominate and are the optimum in the current market environment**, since lucrative grid services are particularly relevant for short storage durations. Furthermore, BESS with short storage durations can better generate additional revenues in (still illiquid) 15-minute markets.
- Outlook: With rising market share of volatile renewable generation, increasing liquidity in the 15-minute market, the cannibalization of revenues from grid services, and appearance of capacity markets, longer storage durations will become relatively more competitive. **This could be in favour of Flow Batteries but they still need to outperform LIB as the incumbent storage technology.**



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By our own power.

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