An auspicious combination: Fast-ramping battery energy storage and high-capacity pumped hydro

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AGENDA

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Market development & current trends
Status quo & trend reversals

The primary powergrids were designed to meet the needs of centralized large-scale carbon-based or nuclear generation facilities.

Today, wind and solar PV increasingly affect the operational characteristics of the powergrids due to temporal and geographic variabilities.

Battery energy storage systems (BESS) represent a game-changer as battery cost drop due to the global e-car development.
The rise of economic-based grid management and control

Future power infrastructures will be an interoperable environment where millions of points of supply and demand exchange information and transact.
Power utilities, TSOs/DSOs*, regulative authorities, government agencies and standards entities develop transactive energy systems (“smart grid”)

* DSO/TSO: Distribution system operator / Transmission system operator


Smart Grid Projects Outlook 2014
Realisation project: 12.5 MW BESS at existing PSP in Germany

Owner & operator: ENGIE Germany

Max. output / capacity: 12.5 MW / 13.5 MWh

25,400 Li-Ion cells in 4 containers (40 ft, 45 t)

1 power converter container

3 x 4.0 MVA step-up transformers 20/0.4 kV

110 kV grid connection

9 mth from contract signature to grid operation
Reserve power markets
ENTSO-E frequency control scheme

R1 / Frequency Containment Reserve (FCR)
Automatic complete activation within 30 s
Provisioning period: $0 < t < 15$ min

R2 / Automatic Frequency Restoration Reserve
Compensation control zone & frequency
Complete activation within 5 min

R3 / Manual Frequency Restoration Reserve
Activation 15 min from telephone call
Provisioning period: $t > 15$ min
Requirements for FCR market
Storage requirements for prequalification in FCR Market

IGCC* revised the criteria for energy resource limited storage devices (i.e. BESS)

15-minutes criteria

- 1 MW / 1 MWh (or 10 MW / 10 MWh) BESS prequalifies for 1 (10) MW FCR capacity
- Now allowed to operate between 25% and 75% SoC (State of Charge)

* International Grid Control Cooperation is a successful initiative of ten TSOs from seven countries (Austria, Belgium, Czech Republic, Denmark, Germany, Netherlands, Switzerland) which started in October 2011
### Qualifiable reserve capacity

#### Ratio usable energy capacity to prequalified R1 power capacity

- **minimum SOC 15min criteria**
- **maximum SOC 15min criteria**
- **minimum SOC 30min criteria**
- **maximum SOC 30min criteria**

**Admissible Operation area**

**Old 30-minutes criteria**

**New 15-minutes criteria**
Admissible operation points for the provision of FCR reserve

Frequency drops down to 49.8 Hz until \( t_2 \)

Frequency goes up to 50.2 Hz until \( t_4 \)

Ramping speed: FCR capacity to be fully available after 30 s (BESS faster!)
Complementing PSP with BESS
Complementing high-energy PSP with fast-ramping BESS

- A 1 MW / 1 MWh BESS prequalified for 1 MW FCR capacity has to stay in the limit $25\% \leq \text{SOC} \leq 75\%$

- BESS relies on a sound re-charging / re-discharging strategy, which can intervene when the BESS itself is not able to stay in SoC limits. Due to the larger autonomy, **PSPs are suitable installations for adjusting BESS’s SoC by delivering/drawing power to/from the BESS.**
Complementing high-energy PSP with fast-ramping BESS

- Conventional fix-speed pump-turbine PSPs are too slow for complying with FCR ramping requirements

- Only if a PSP is equipped with a ternary set (motor-generator, separate turbine and pump), it can provide FCR if operated in so-called hydraulic short-circuit mode

- BESS are much faster than ternary set PSPs due to converter control (electro-chemical process & power electronics, no mechanical elements)
BESS bridges PSP latency
BESS increases PSP ramping capability

![Graph showing BESS increases PSP ramping capability](image-url)
Conclusion: PSP & BESS are natural partners in dynamic grids

- Battery Energy Storage Systems are an **enabling technology** for power systems with high share of **renewable energy generation**

- By operating BESS & PSP jointly under one regime, the control aggregate can benefit from **fast ramping functionality (BESS)** & **high storage capacity (PSP)**

- The hydro **asset performance can be improved** by upgrading the secondary control functionality (R2) to the **more profitable frequency containment reserve market (R1)**
Recommendation: Study potential to improve PSP performance

- With the presented concept, PSP can provide higher flexibility to power systems, which is more and more requested in grids with large RE-infeed.

- As most existing and planned PSPs dispose infrastructure* for being complemented with BESS, it is worth to perform a pre-feasibility assessment.

* e.g. high voltage grid connection point, control and monitoring system, link to dispatch, O&M capabilities.
THANK YOU FOR YOUR ATTENTION
YOUR QUESTIONS ARE WELCOME

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