Recent progress of stack generations for a 40 kW all-vanadium flow battery as part of a multifunctional hybrid compensator

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Background and project focal points

The aim of the project HYBKomp is the development and implementation of a multifunctional hybrid compensator to provide various ancillary services in medium-voltage grids with a single device (as shown in Figure 5). These services are for example a fast and flexible compensation of grid fluctuations, correction of voltage distortion or earth fault compensation.

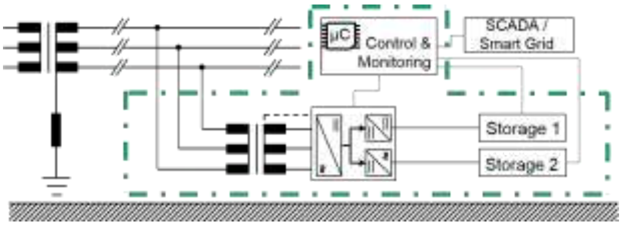

Figure 5. Connection structure of the hybrid compensator [1]

A core element of the project is the realisation of a 40 kW flow battery as a buffer storage and pilot plant for cell and stack concepts.

System structure and dimensioning

With 40 kW power output and a storage capacity of 15 kWh, the flow battery system is dimensioned for short term ancillary services and characterisation tests. The battery system consists of six modules with almost equally power outputs, equipped with different stacks from our own development (as shown in Figure 6).

Stack designs used

The stacks used in the flow battery system are either based on the external electrolyte supply or on the internal supply. In stacks with an external electrolyte supply, each flow cell has a direct outside connection and is supplied separately via external manifolds (as shown in Figure 7).

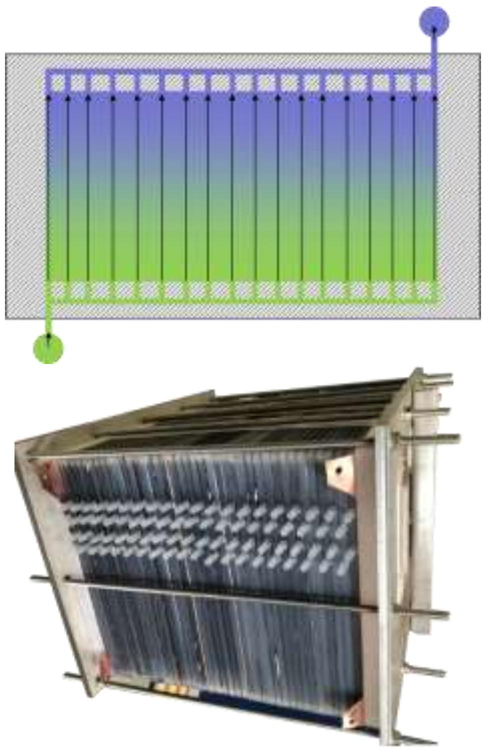

Figure 7. Flow battery stack with external electrolyte supply

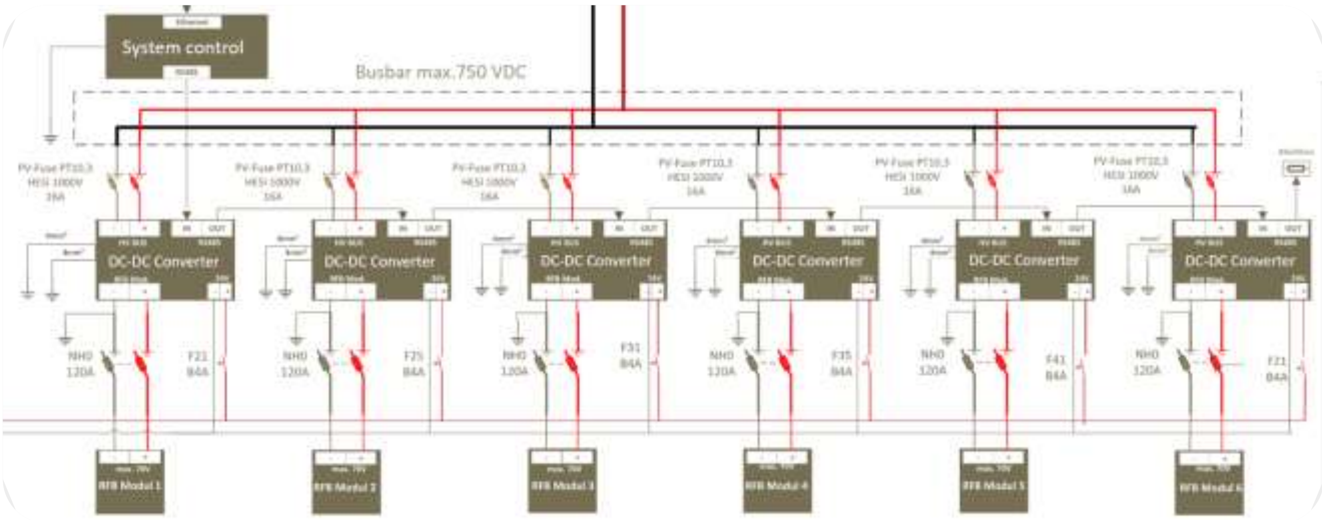

Figure 6. Structure scheme of the 40 kW all-vanadium flow battery system

This design offers the advantage of an easy connection and sealing of cells as well as the possibility to directly monitor and control the electrolyte flow in each individual cell. Disadvantages of this design are the costly production as well as the limited cell thickness, as the supply tubes has to fit in the cell frames.
The internal electrolyte supply is the most common used design for flow battery stacks. In this design, the cells are supplied via internal manifolds and the manifold entries and exits in the end plates are the only outside connection (as shown in Figure 8).

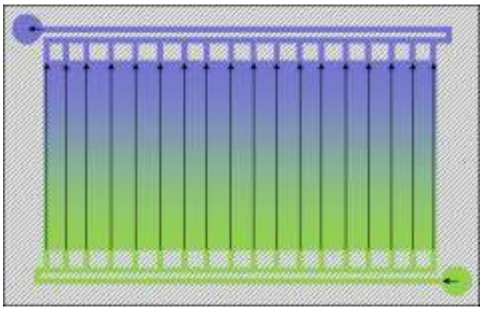

Figure 8. Flow battery stacks with internal electrolyte supply

This stack design is suitable for mass production and require much simpler hydraulic peripherals. The cell thickness is only limited by the type of sealing. Disadvantages are the complex sealing around the internal manifolds as well as the lack of insight into the actual electrolyte distribution on the cells in a stack.

Flow cell designs

The cell designs used in the various flow battery stacks are primarily aimed at reducing pressure losses while maintaining efficiency by using i. e.

- Internal flow field designs, especially interdigitated flow field designs (as shown in Figure 9),
- Different graphite felt thicknesses and degrees of build-in compression,
- Different cell internal channel cross-sections and courses as well as distribution types of the electrolytes.

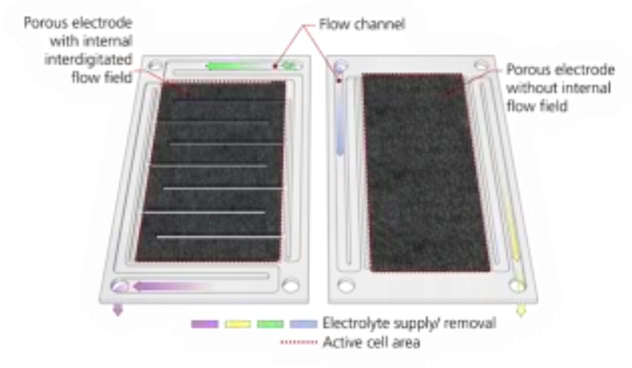

Figure 9. Flow battery with and without an internal interdigitated flow field

Current state and outstanding tasks

The containers for the multifunctional hybrid compensator are set up at the installation site in Haßfurt, Germany. The battery management system via SPS is fully programmed and all sensors, controllers, supply and communication lines are installed. Furthermore, the hydraulic peripherals are installed and tested, several stacks are connected to the system.
The remaining tasks are limited to the production and installation of further stack generations as well as the commissioning of the overall system.

Figure 10. Installed containers for the transformer, fly wheel and power electronics as well as the flow battery

Acknowledgements

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References

[1] J. Girschik et al., 40 kW vanadium flow battery as part of a multifunctional hybrid compensator, *IFBF*, 2019