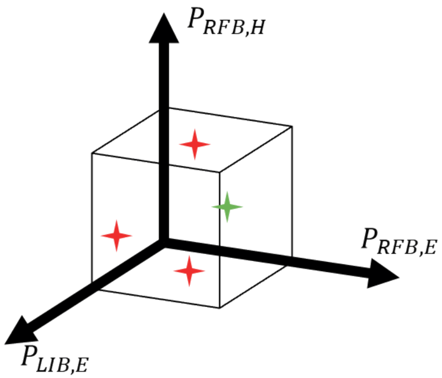
Real-time optimization of setup

The whole setup is controlled through a centralized Energy Management System (EMS), where the operations take place at 250msec raster. The EMS aims at solving a multi-objective optimization problem with the following aims:

- Improve economic performance of VRFB and LIB by reducing operation losses and standby consumption
- Maximize waste heat utilization of VRFB
- Reduce aging of VRFB and LIB
- Improve setup self-sufficiency in terms of electricity and hot water requirement



$P_{LIB,E}$ → Electrical load of LIB
$P_{RFB,E}$ → Electrical load of RFB
$P_{RFB,H}$ → Thermal load of RFB

3-dimensional optimization problem

Chanllenge: Operational efficiency of VRFB is not only dependent on its electrical but also thermal state. The unique dual usage of VRFB creates a new 3-dimensional optimization problem statement where the EMS must find the optimum operation point in the operation volume, where the hybrid storage system is not only optimized in electrical terms, but the VRFB is also optimized in thermal terms as visualized above.

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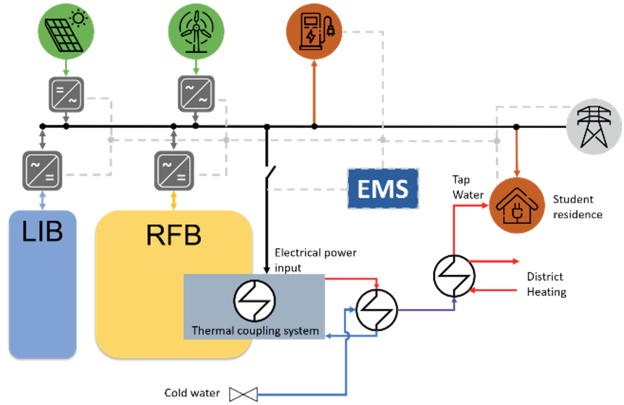
Development of a Vanadium redox

Flow battery hybrid system as a storage system for integration into heat and electricity supply

Innovative storage system

The project setup located in a student residence in Bruchsal, Germany, aims to prove the following innovation steps:



Real-life Multi Energy system setup

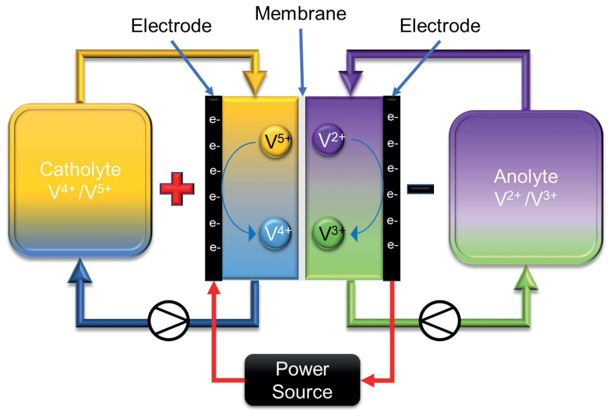
Hybrid storage in application:
A vanadium redox-flow (VFRB) and lithium-ion battery (LIB) are installed to function as hybrid energy storage. With an optimal operation strategy, this system might reach higher efficiencies than their parts.

Increase of the overall efficiency of the VRFB:
VRFB show much lower efficiency when cycled (approx. 70%). A new thermal coupling system is designed to recuperate most of the heat losses and therefore aims to reach overall efficiencies of >90%.

Innovative dual usage of VRFB as heat storage:
Furthermore, the VFB is adapted to store heat within their electrolyte tanks. Opening possibilities for cost and space effective sector coupling for the energy transition.

1st Flow BiFlow-Demonstrator

The vanadium redox-flow battery (VRFB) has a nominal power of 20 kW and capacity of 100 kWh (upgradeable to 200 kWh). Due to the VRFBs modified electrolyte composition, it operates at an expanded temperature range of 10 - 55°C. Each electrolyte tank is equipped with a 30 kW heat exchanger, transferring excess heat from the VRFB to the heating infrastructure of the building.



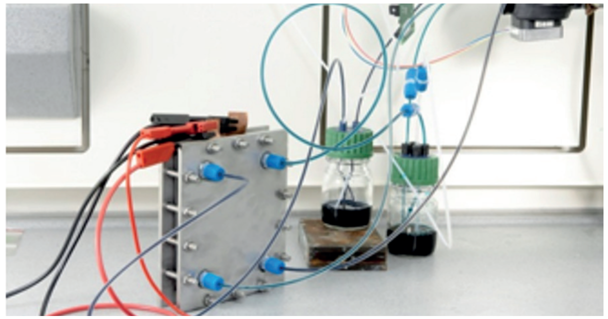
Scheme of a vanadium flow battery

Features:

- Cycle life > 20 000 cycles
- Product lifetime exceeding 20 years
- Recyclable electrolyte and battery components
- Neither flammable nor explosive
- Independent power to capacity ratio
- No degradation of capacity during operational lifetime

Adaptation of electrolyte for dual use

- Adaptation of VFB electrolyte for dual (electrochemical and thermal) use in the range of 10 °C - 50°C
- Investigation of the relationship between electrolyte formulation and the operating characteristics of at elevated temperature.



Flow cell set-up for electrolysis and charge-discharge tests

Challenge:
Current VFB electrolytes operating temperature range is 0 °C - 35 °C. Vanadium tend to condense irreversibly to vanadium pentoxide at around 40 °C. Following solutions are investigated:

1. Use of additives, which stabilize pentavalent vanadium solutions and prevent flocculation of vanadium oxides
2. Use mixtures with sulfuric acid, adjustment of vanadium to sulfuric acid concentrations.

Approach:
By diluting the electrolyte with acid, the thermal stability of electrolyte can be enhanced at the expenses of battery capacity → compromise between stability and capacity is investigated.

Output:
extended specifications for V electrolytes