

Redox Flow Battery

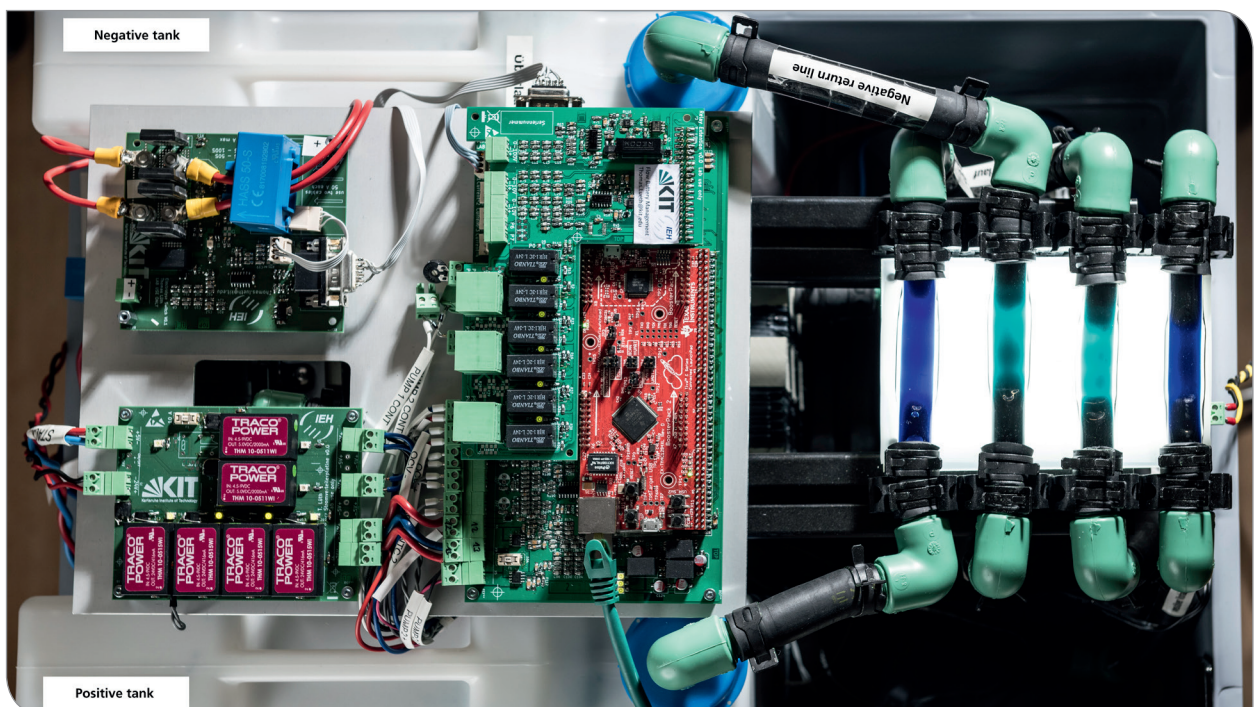
System Components and Materials Sciences for Efficient and Sustainable Redox Flow Batteries

Energy storage systems are important components of the power grid in times of transition to renewable sources and the basis of reliable and inexpensive power supply. Generation of electrical power today is experiencing a paradigm shift from large central power plants to decentralized modular production from renewables and conventional sources. As a consequence, planning of production is more difficult, thus causing an extension of transmission grids and energy storage systems.

This trend can also be observed in storage technology. Due to the enormous space and capital requirements, large pump-storage power plants are neither acceptable to the majority nor economically efficient. A good alternative are decentralized storage solutions. Several concepts are feasible, from the classical lead acid battery and the currently well-established lithium-ion technology to the innovative redox flow battery technology.

The Institute for Applied Materials (IAM) and the Institute of Electric Energy Systems and High-Voltage Engineering (IEH) study options to reduce the costs and enhance reliability of the redox flow battery technology. The redox flow battery has a number of advantages that make it suitable for medium to large storage projects. Power (kW) and energy (kWh) can be scaled independently of each other, a simple example being the shift of solar energy into the night.

In contrast to other batteries, the vanadium redox flow battery (VRFB) exclusively uses vanadium in four oxidation states for the redox pairs. In the negative half cell, vanadium of oxidation state +II/+III is applied. In the positive half cell, vanadium +IV/+V is used. This excludes cross contamination of the redox pairs and increases the service life of the battery. Among the drawbacks are the high corrosiveness of the electrolyte and the associated very strict

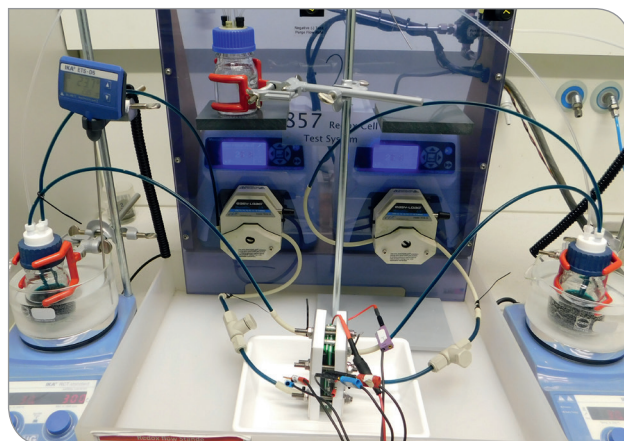


The KIT-developed battery management system (prototype) for decentralized monitoring and control of redox flow batteries enables “stand-alone” operation without additional intelligence

requirements on the materials used as well as self-discharge of the battery through the permeable membrane.

In order to promote targeted material development for all components (electrodes, electrolyte, membrane), their degradation processes in operation have to be understood. The IAM is therefore currently studying the degradation processes of the membrane. These membranes are subjected to accelerated life time tests both electrochemically under close-to-reality conditions in the cell and by chemical, thermal, and mechanical processes. Comparison of the membranes aged inside and outside of the cell provides for a better understanding of the underlying degradation processes. With the newly developed accelerated aging methods, new materials can be tested and qualified with respect to stability far more quickly.

The IEH is presently working on the development of a decentralized, modular management system and is testing it together with industry partners. The above-mentioned advantage of independent scalability of power and energy cannot yet be fully used, as this would require adaptation of each battery to be installed. To overcome this limitation, the management system developed by IEH is designed for the completely autonomous and decentralized management of a battery cluster, if required. By means of a higher-level control, the system can be influenced and process data are available at any time. This allows for the assembly of battery modules that only remain to be connected to the media supply at the place of installation. Field wiring of sensors is no longer required. Decentralized control of the battery enables operation of each battery cluster at maximum efficiency, while the measurement and control data arising can be stored at low cost.



KIT test rig for materials testing on the laboratory scale with 10 cm² active cell surface and 100 ml tanks

Technical Equipment

- Two VRFB test benches
- Complete tool chain for the development of control components
- Laboratory for electromagnetic compatibility (EMC) tests
- Electronics laboratory and test equipment
- Chemical laboratory with VRFB test benches
- Analytics: Among others, Raman spectroscopy, FTIR-coupled thermal analysis, X-ray photo electron spectroscopy, nuclear magnetic resonance, scanning electron microscopy, tensile test rig

Goals

- Development of a decentralized battery management system
- Increased energy efficiency by decentralized control
- Understanding of degradation processes in the battery, in particular of the membrane
- Development of processes for accelerated aging

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