Valuation methodology for the risk and performance analysis of non-hazardous flow battery chemistries

Milan Selle, Jan Girschik, Jens Burfeind, Anna Grevé
Fraunhofer UMSICHT, Oberhausen, Germany
Email: milan.selle@umsicht.fraunhofer.de

Introduction

ndande As vanadium oxide compounds have recently been classified as carcinogenic, the question arises as to whether the all-V RFBs should still be used.
But are there chemical systems that can replace V-RFBs?
In order to answer these questions, various battery chemistries are subjected to a risk analysis and compared.
However, risk analyses alone will not lead us to new and useful solutions. For this reason, performance parameters will be included in the analysis as well as risk factors.

Motivation

The aim of this work is to develop a use case dependent and standardized evaluation procedure for flow-battery-chemistries. This procedure should make it easier to find the right chemistry for specific framework conditions. In a further development, it should be possible to evaluate half-cells individually. This could result in a meaningful tool for future battery research.

Methodology[1, 2]

The model is based on a utility analysis. Influential criteria are determined and evaluated using measurable indicators. For the evaluation, the measured values of the indicators are subjected to a transformation and then weighted. Both the weighting and the transformation are in turn dependent on the use case.
In most risk assessments, the probability of occurrence is plotted against the expected loss. The result is then referred to as the risk. In the selected approach, the risk is included directly via the weighting factor of the individual risk indicators.
A conversion of the assessment into purely monetary values can be achieved through a cost-benefit analysis. This changes the approach to the effect that the valuation and conversion are no longer dependent on the use case.

Criteria and Indicators[3]

Only the two most important criteria were evaluated in the model, namely the risks associated with the chemicals used and performance parameters.
For the most influential indicators of the performance parameters, depth of discharge, current density, energy density, cyclic stability and energy efficiency were determined.
The most important risk indicators were identified as corrosiveness, toxicity, carcinogenicity and fire risk. In contrast to the performance data, these indicators are not all directly quantifiable. For corrosivity, the pH value of the solution serves as an indicator. Toxicity is determined via the LD50 value. The indication for cancer risk and fire hazards is graduated, for cancer risk a distinction is made between proven, probable and non-carcinogenic. For fire risk, the solvent is divided into highly flammable, flammable and non-flammable.

Use cases

The aim of this work is to develop a use case dependent and standardized evaluation procedure for flow-battery-chemistries. This procedure should make it easier to find the right chemistry for specific framework conditions. In a further development, it should be possible to evaluate half-cells individually. This could result in a meaningful tool for future battery research.

Table 1: example ratings of the chosen criteria in depoendance of use cases

Rating	Use case 1	Use case 2	…	Use case n
Performance	50	60		
Depth of discharge	15	10		
Current density	20	25		
Energy density	15	10		
Cycle stability	30	25		
Efficiency	20	30		
Risks	50	40		
Corrosion	25	30		
Toxicity	30	30		
Carcinogen	20	10		
Fire hazard	25	30		

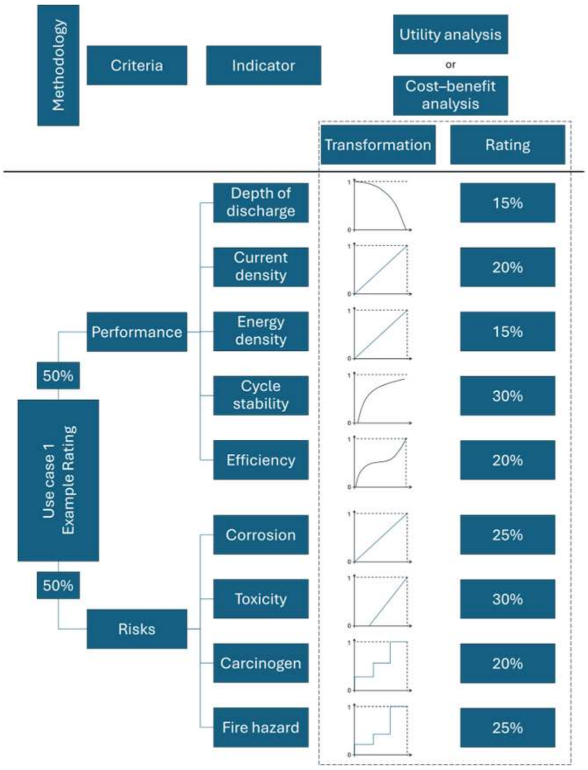

Figure 1: Schematic representation of the utility analysis based on an example use case

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[1] B. Funke, T. Rohlfs, Risikomanagement im Versicherungsunternehmen, 1st ed., Karlsruhe: Verlag Versicherungswirtschaft, 2023.
[2] L. R. Keeney, H Raiffa, Decisions with multiple objectives:Preferences and value tradeoffs; New York: Wiley, 1976.
[3] J. Richardson, "Cost utility analysis: what should be measured?" Social science & medicine Vol. 39, No. I, pp. 7-21, 1994.