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Large scale energy storage
Investigating improvements on redox flow batteries

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INTRODUCTION

Renewable energy sources are receiving increased attention. However, the intermittent nature of many sources (e.g. solar, wind, tidal and wave energy) makes them unreliable especially for off-grid applications. Batteries are usually employed as buffers between the lag of generation and usage, so that a constant energy output is achieved.

The main objectives of this study were to investigate alternatives to the currently available redox flow batteries. Suitable couples were identified, and their performance was tested in a lab-scale redox flow battery. Improvements to the performance of the tested cell was achieved by identifying key parameters and investigating their effects on the performance of the cell.

BACKGROUND TO A REDOX FLOW BATTERY

The main difference between a redox flow battery and a conventional battery is that for a redox flow battery, the reactants stay in liquid solutions. This has the advantage of decoupling the energy storage capacity and power rating of the battery because the electrodes act as current collectors and are not part of the reactions.

A disadvantage however is the low power densities and this limits the applications of redox flow batteries to mostly stationary applications (where mass is not really an issue) and where the larger size will be negated by the higher energy output.

Commercially available redox flow batteries include the zinc-bromine (Zn-Br) battery (a pseudo redox flow battery) as well as the allvanadium (V-V) battery. Each of these has its own intrinsic problems. The CSIR investigated alternatives to the V-V battery to reduce the cost of the electrolyte, and these results are presented here.

EXPERIMENTAL

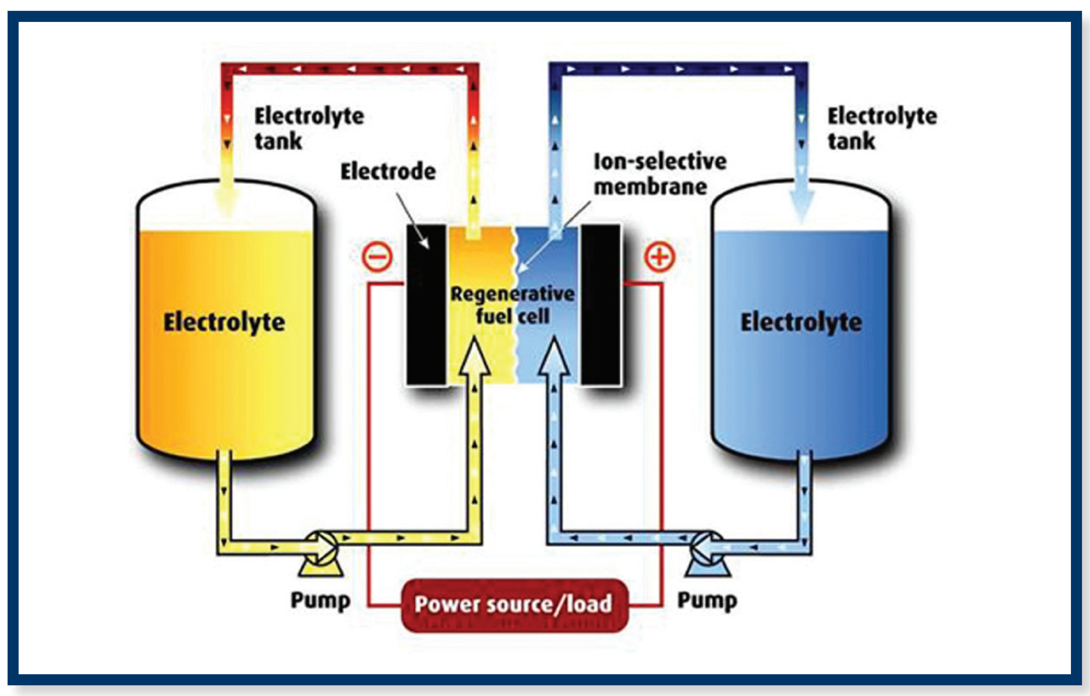


Figure 1: Schematic representation of the cell used during testing

The cell employed a graphite felt electrode (5cm x 7cm x 0.3cm) in each half-cell and a current collector. The current collectors tested were aluminium, copper or platinum. Peristaltic pumps circulated the electrolyte through the cell via flow frames containing the graphite electrodes. A membrane separator was placed between the two flow frames to separate each half-cell.

Because of the instability of V^{2+} in oxygen/air, nitrogen was sparged into the reservoir to provide an inert atmosphere.

VANADIUM-BROMINE REDOX BATTERY

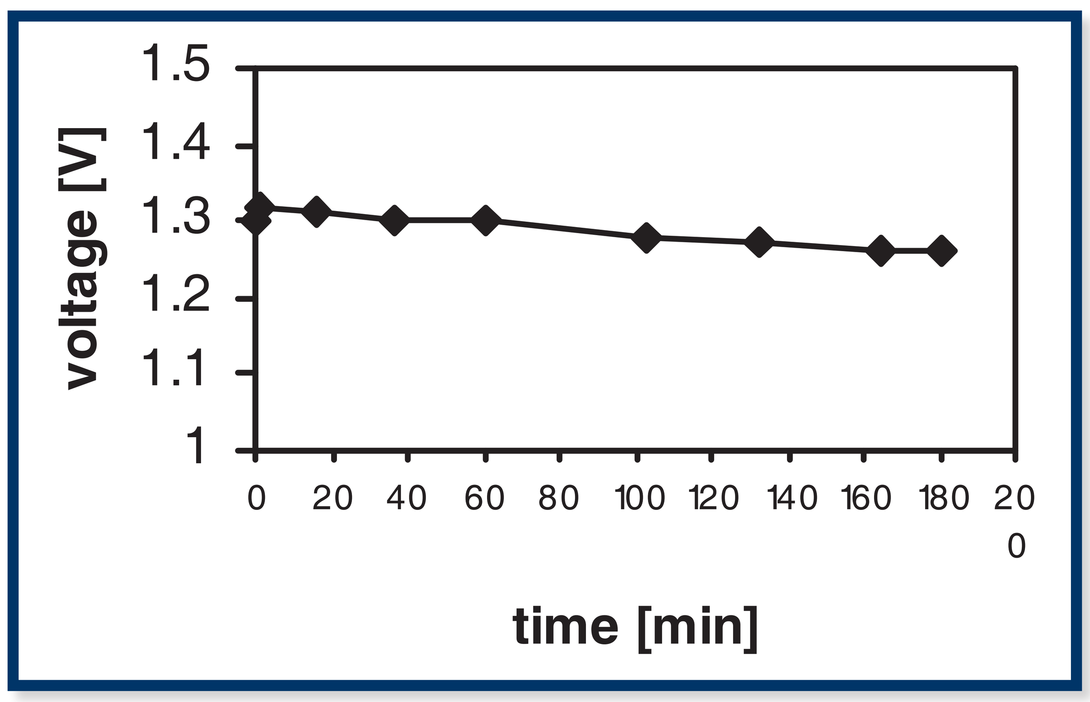


Figure 2: Open circuit voltage for the V-Br battery

Constant open-circuit voltage indicates very little cross-contamination. Cost of V-V reduced by up to 40%.

CHROME-BROMINE REDOX BATTERY

An alternative to the vanadium-bromine battery was also tested at the CSIR to further investigate improvements on the cost and power densities of the redox flow battery. The C-Br battery showed promise in terms of the power outputs as shown below. Furthermore, the cost of such a battery electrolyte would be cheaper by up to 70% than the all vanadium battery.

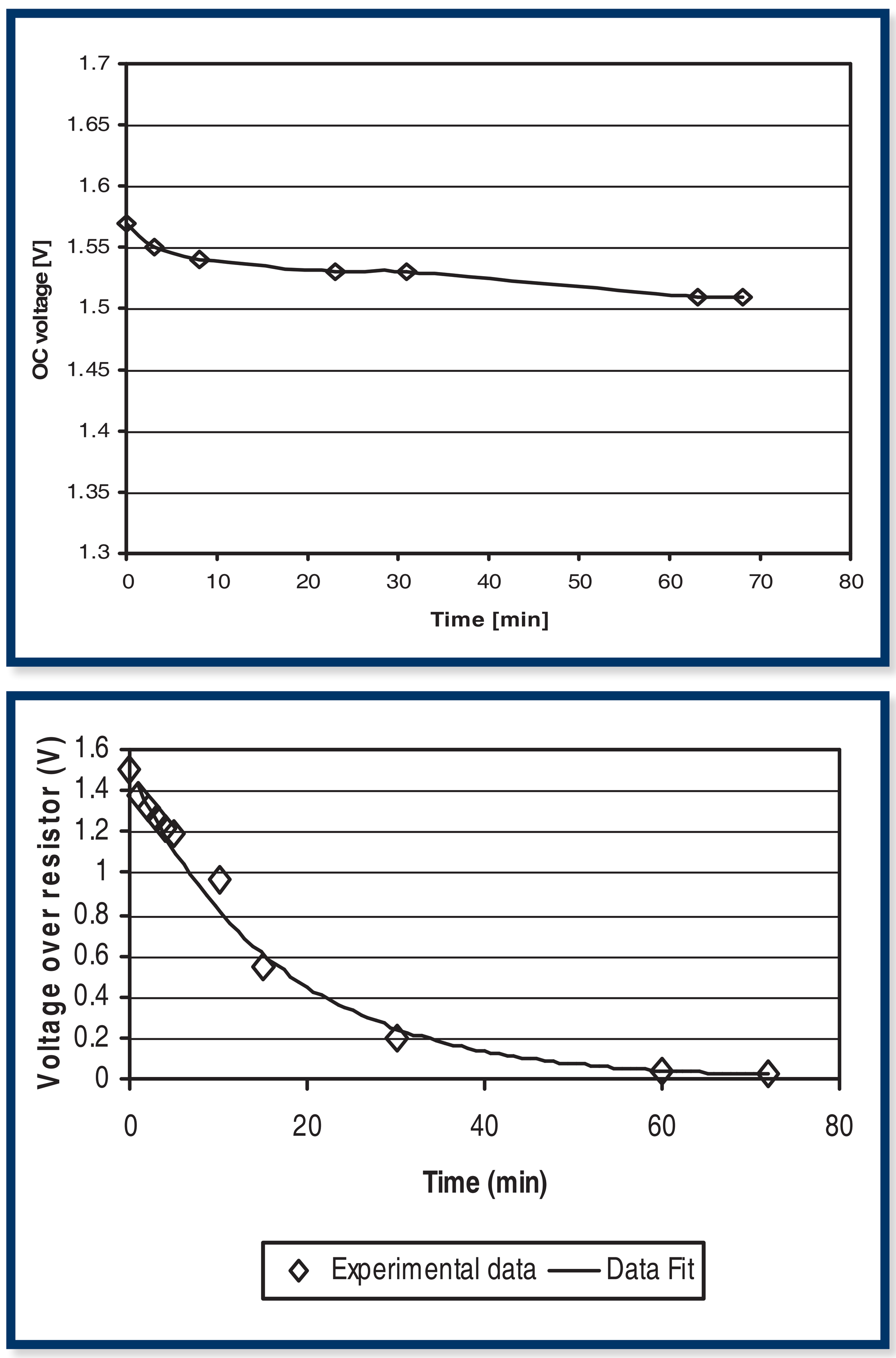


Figure 3: Discharge curves for the Cr-Br battery

CONCLUSIONS

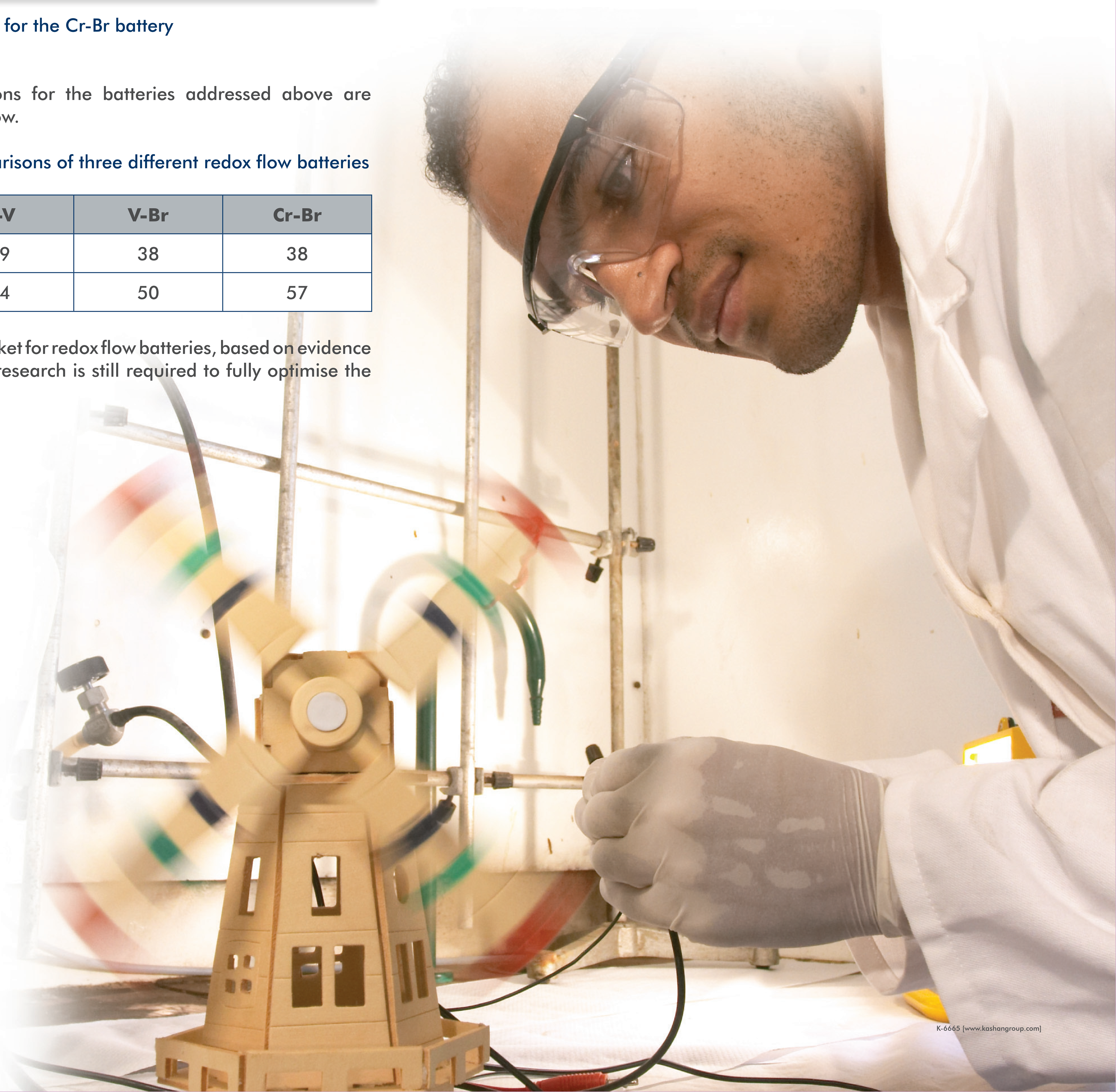
The theoretical comparisons for the batteries addressed above are presented in the table below.

Table 1: Theoretical comparisons of three different redox flow batteries

Battery	V-V	V-Br	Cr-Br
Ah/kg	19	38	38
Wh/kg	24	50	57

There exists a potential market for redox flow batteries, based on evidence presented above. Further research is still required to fully optimise the battery outputs.

To make the most of renewable energy sources such as solar, wind, tidal and wave energy, their intermittent nature must be neutralised by using large-scale energy storage batteries. CSIR researchers are investigating better-performing redox flow batteries for this purpose.



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