How do we build the supply chain for flow batteries?

IFBF

IFBF Presentation

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BUSHVELD ENERGY

A little bit about me

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- Co-founder and Chief Executive Officer of Bushveld Energy, an energy storage solutions company, part of AIM-listed Bushveld Minerals, an integrated vanadium company
- Chairman of the South Africa Energy Storage Association (SAESA)
- Chair of the Energy Storage Committee of Vanitec, the global association of vanadium producers
- Previously worked for McKinsey & Company in Russia and across Africa, focusing on the power sector (strategy and plant operations) and economic development. Mikhail's corporate career started as a commercial banker in the USA

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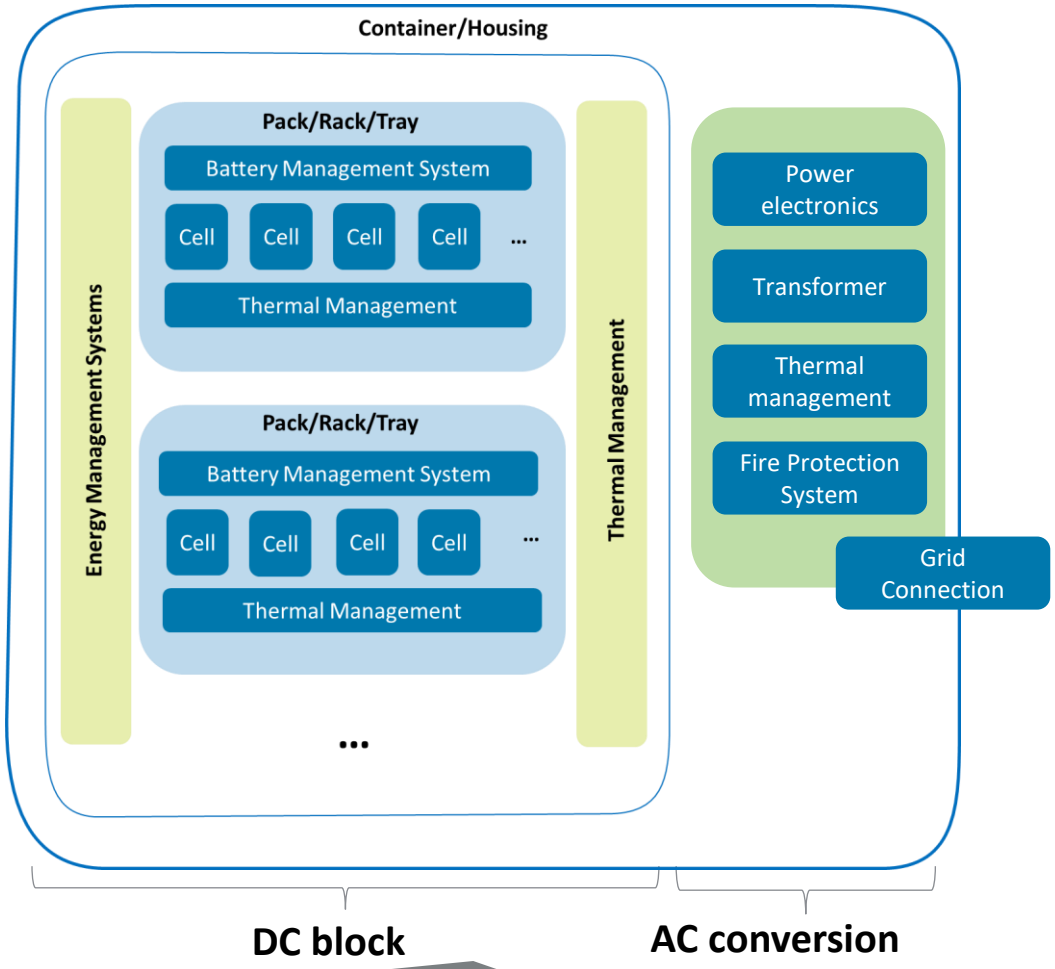
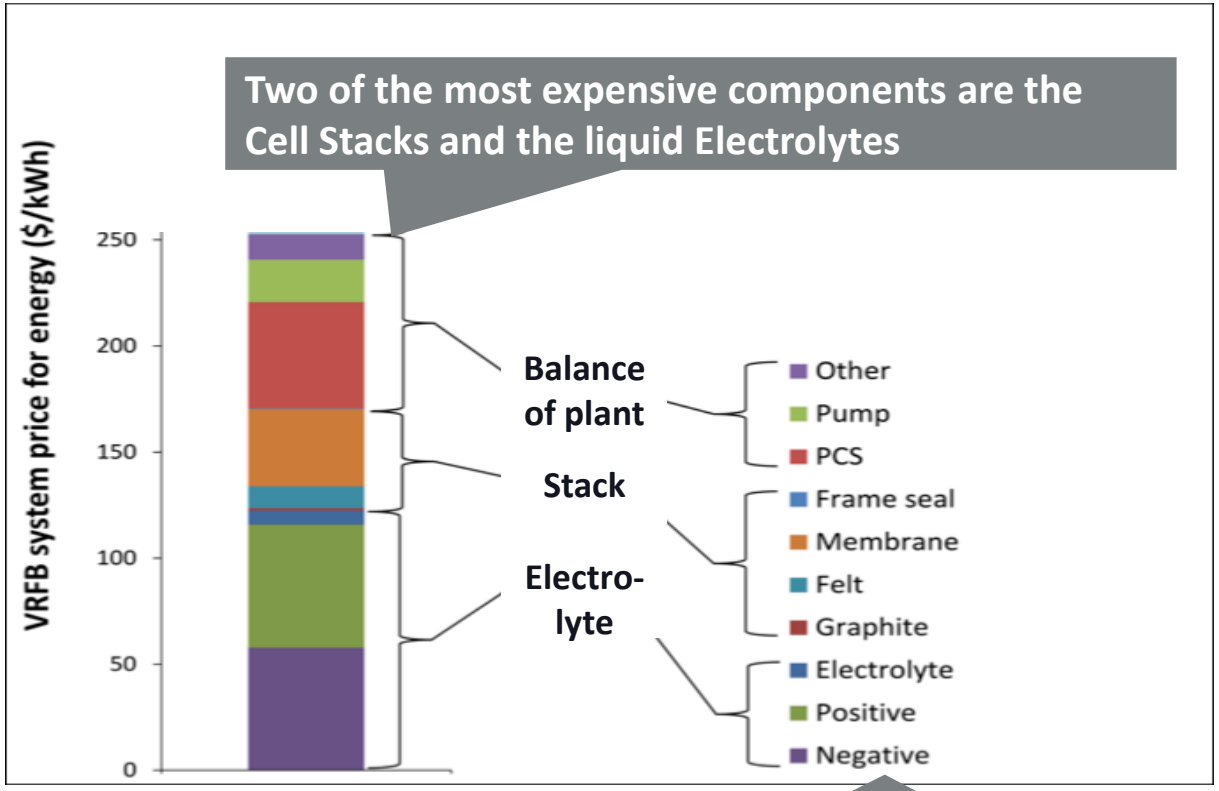
Energy storage systems, including batteries, consist of multiple components that must be considered in the supply chain

Major components of a battery system



Key components of a flow battery DC block (VRFB example)



Most of the technical differences among systems are on the DC side

Source: IRENA; Joint Center for Energy Storage Research (JCESR)

Component example: what could be done to reduce costs on cell stacks and electrolyte?

	Cost decrease methods (not exhaustive)	**Supply chain requirements** (not exhaustive)
Cell stack	• Reduce cost of sub-components	• R&D to simplify design and use cheaper materials; buy in bulk;
	• Manufacture faster / automate production	• Increase production volumes to justify semi- or full automation of stack assembly
	• Other levers	• Reduce shipping & transactions costs; etc.
Electrolyte	• Increase energy density	• R&D on electrolyte compositions
	• Reduce cost of electrolyte manufacturing process	• Reduce conversion costs (cheaper facilities, lower margins/higher volumes, new processes)
	• Reduce price of supplied commodities (e.g. vanadium)	• Reduce quality requirements; sign long term off-take or buy in bulk to obtain discount
	• Replace with cheaper materials / reagents	• Substitute more expensive minerals and reagents with cheaper ones (in part or fully)
	• Other levers	• Reduce shipping & transactions costs; overlay financial products to reduce cash needs; etc.

Economies of scale are important in many of these

Sources of major risks and opportunities for suppliers, such as Bushveld

Source: Bushveld Energy

Example: Bushveld's activities as a flow battery value chain participant?

1. Ensure there is enough vanadium

- There is more than enough vanadium in the ground;
- Grade is a key factor, so exploration activities are critical to grow the resource base;
- Bushveld holds the largest primary vanadium resource in the world

2. Build manufacturing scale, where we can

- Processing vanadium-containing ore is capital intensive;
- Expansion of existing facilities or construction of new steel or dedicated plants is needed;
- Bushveld has committed to nearly triple production in short to medium term

3. Partner with VRFB companies to innovate

- Innovation is needed to reduce battery costs and improve sustainability;
- Bushveld is collaborating with many VRFB companies on a multitude of
  - Electrolyte requirements
  - Electrolyte rental
  - Electrolyte recycling
  - Invested in OEMs

4. Deploy systems to help grow scale

- Installing a VRFB-led minigrid at one of our mines (together with solar PV);
- Built a project development team to deploy VRFBs in Africa;
- Co-deployed a system with the national utility that only had lithium

Not everyone approves us doing so much, including even some VRFB companies, but the alternative is "nothing"

5. Communicate and share the above activities to increase awareness: IFBF, Vanitec, SAESA, funders, conferences, journals, etc.

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Source: Bushveld Energy