Advancing Vanadium Flow Battery Technology for Grid-Scale Markets

H. Chhina, A. Klassen, B. Adams

Invinity Energy Systems, 1250 E Pender St, Vancouver BC, V6A 1W8 Canada Invinity.com *Email: Harmeet Chhina - hchhina@invinity.com*



Introduction

Invinity Energy Systems (IES) has been deploying utility-scale Vanadium Flow Battery (VFB) Energy Storage Systems (ESS) since 2020 in the UK, USA, Australia, and Canada. Over the past five years, IES has:

- Deployed VFB projects with the VS3 product platform at sites with capacities of up to 10 MWh, discharging >5.5 GWh since 2022.
- Evolved key architectural and technology advancements leading to improved system performance and lower cost in the newly released ENDURIUM[™] product (Figure 1), which was developed and commercially launched with Siemens Gamesa, a wholly owned subsidiary of Siemens Gamesa Renewable Energy (now ABB).

Figure 1: Configuration of a 3 MW / 12 MWh Endurium Array



Endurium Architecture

Endurium utilizes four electrically connected modules in series to form a "string" that matches storage industry-standard 1500 VDC AC/DC inverters. This eliminates DC-DC converters in the storage circuit, simplifying the system's electrical, controls, and mechanical architecture, resulting in the following benefits:

Figure 2: Endurium Module (Top) and Endurium 4-module string deployed at Gamesa Electric V-iOn Project, La Plana, Spain (Bottom).



Table 1: Key Product Improvements

	VS3		Improvement
Specific Energy MWh/acre	42	100	138%
Tanks and Pumps	12	2	83%
Battery Controllers	7	2	71%

1. Higher Specific Energy

Endurium is designed to deliver the highest specific energy of all nonlithium batteries for Grid-Scale markets via IES's proven modular "plug and play" approach, with specific energy of 100 MWh/acre, similar to lithium batteries (Figure 2 and Table 1). This maximizes land-use efficiency, reduces project installation cost and time, and allows installation at existing grid operators and Industrial sites.



2. Cost Reduction

Endurium was redesigned and optimized to increase performance (higher power, energy capacity, RTE%, cooling capacity, etc.) while lowering capital costs. Other improvements include a scalable, robust, and verified control system, a proprietary electrolyte formulation achieving > 21 Wh DC discharge energy per litre of electrolyte, improving serviceability, operations & maintenance (O&M) costs. Together, these changes result in a best in class levelized cost of storage (LCOS). Endurium battery performance has also been extensively tested and verified (Figure 3), confirming the product fully meets specifications.

Figure 3: Endurium String BESS Performance



Conclusions

The Endurium product , designed specifically for grid-scale LDES markets, has achieved a high specific energy of 100 MWh per acre, electrolyte DC energy output density exceeding 21 Wh per litre, and an extensively tested and verified performance specification while reducing both its capital and O+M costs.

Its modularity provides exceptional BESS array flexibility, allowing it to be rapidly deployed on projects ranging from 12 to 1000+ MWh, with durations of 4 to 18 hours.

